Electrical Engineering

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FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Date*	*Nature*	*Latest Date for Receipt of Manuscripts*
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	(Closed)
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May 4-7, 1932	District Meeting	Feb. 4, 1932
Cleveland, Ohio	June 20-24, 1932	Summer Convention	March 20, 1932
Vancouver, B. C.	Aug. 29-Sept. 2, 1932	Pacific Coast Convention	May 29, 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute Headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

NATIONAL RESEARCH COUNCIL, fourth annual conference of committee on electrical insulation of the division of engineering and industrial research, Harvard University, Cambridge, Mass., November 13-14, 1931. (J. B. Whitehead, chairman, Johns Hopkins University, Baltimore, Md.)

THIRD INTERNATIONAL CONFERENCE ON BITUMINOUS COAL, Carnegie Institute of Technology, Pittsburgh, Pa., November 16-21, 1931. (T. R. Alexander, secretary, Schenley Park, Pittsburgh, Pa.)

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, annual meeting, Engineering Societies Building, 29 West 39th Street, New York, N. Y., November 19-20, 1931. (Thos. C. Kain, secretary, 29 West 39th Street, New York, N. Y.)

AMERICAN PHYSICAL SOCIETY, 173rd regular meeting, Ryerson Physical Laboratory, Chicago, Ill., November 27-28, 1931; 174th regular meeting, Pacific Coast, Berkeley, Calif., December 18-19, 1931. (W. L. Severinghaus, secretary, Columbia University, New York, N. Y.)

PACIFIC COAST ELECTRICAL ASSOCIATION, engineering section, Los Angeles, Calif., December 9-11, 1931. (K. I. Dazey, secretary, 447 Sutter St., San Francisco, Calif.)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, annual meeting, New Orleans, La., Jan. 2, 1932. (Chas. F. Roos, secretary, Smithsonian Institution, Washington, D. C.)

AMERICAN ENGINEERING COUNCIL, Washington, D. C., January 14-16, 1932. (L. W. Wallace, 744 Jackson Place, N. W., Washington, D. C.)

SOUTH AMERICAN ELECTROTECHNICAL CONGRESS, Buenos Aires, July 4-11, 1932. (R. F. Ascher, general secretary, Paseo Colon 185, Buenos Aires, S. A.)

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This Month—

Front Cover

Lower Leevining Creek hydroelectric plant of the Southern Sierras Power Company, California.

—Electrical West Photo.

—— Turn to Next Page

PLANS already are being made for the 1932 A.I.E.E. winter convention. *(See p. 908-9.)*

POWER equipment of unusual design and proportions was required for KDKA's new high power transmitter. *(See p. 865-8.)*

HOUSED in the new Waldorf-Astoria Hotel in New York is an electrical program distribution system involving many novel features. *(See p. 895-7.)*

INCREASED attention now is being focused upon oil filled cable and upon means of simplifying its installation, for transmitting electric power at high voltages. *(See p. 874-82.)*

DISCUSSION on a variety of articles published in ELECTRICAL ENGINEERING has come to the editor during the past month. Some of these may be found in this month's "Letters to the Editor" columns. *(See p. 909-10.)*

ABSTRACTS of the eighteen technical papers presented at the recent Kansas City District meeting are given in this issue, in order that interested parties may order copies of the complete papers without delay. *(See p. 900-3.)*

REVERSING the usual order by setting up electrical analogies for complicated mechanical systems, sometimes provides a simpler method of solution for solving difficult mechanical problems. *(See p. 862-5.)*

WITH 25 years' professional engineering experience in the U. S. A. and a recent eighteen-month engagement in the U.S.S.R., a native of Russia gives some interesting sidelights on that country's much discussed industrial development. *(See p. 883-5.)*

EDISON, the newsboy, telegrapher, inventor, creator of innumerable devices and processes underlying in no small way the modern commercial and industrial development of the world, has been cited for his Final Reward. His life's work has had great effect on pure and applied sciences. His dominating motive was creation. His indomitable will and devotion to his work will stand as historical monuments to inspire and to encourage those who follow. The Institute with the world mourns his passing. *(See p. 904-7.)*

Field Studies of Arcing Faults on Power Lines

Experimental studies of arcing faults on a 75-kv. transmission system indicate that a lightning flashover is most likely to develop into a power arc when power current is flowing past the flashover point, when normal-frequency voltage is increased, or when line insulation is decreased.

By
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J. K. PECK — Associate A. I. E. E. — National Elec. Lt. Assn., New York

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A DISCUSSION of the continuity of service which can be maintained on a power system frequently involves the consideration of power arcs. In spite of the acknowledged importance of arcs in the operation of power systems, there is but little available experimental information concerning the causes of power arcs which follow surges, the characteristics of arcs, or the resulting effects of arcs. The results of cooperative experimental investigations made by the Consumers Power Company, Jackson, Mich., the General Electric Company, and the joint development and research subcommittee of the National Electric Light Association and Bell system, to study the character of arcing faults are discussed here.

Factors Governing the Power-Arc Development

Operating data presented in the past few years have indicated that lightning frequently may cause sparkover of transmission-line insulators without producing a power arc. Although the spark and the arc are quite different in nature, there is no sharp line of demarcation between the two, and the transition from one to the other is but little understood.

To investigate experimentally the factors governing the transition of an impulse flashover into a power arc, impulses from a 1,500-kv. lightning generator were applied to a transmission-line conductor energized to ground through a transformer bank. The line insulation was such that in every case flashovers occurred at a predetermined test tower where the amount of insulation was varied at will. The length of the transmission line beyond the test tower could be changed from a few feet to 35 mi.; with the 35-mi. line the total charging current of the three-phase line flowed past the flashover point, thus simulating a load on the line.

The curves shown in Fig. 2 give the results of 278 tests in which the applied 30-cycle voltage, the flashover distance, and the condition as to whether or not current was flowing past the flashover point were varied. The point on the 30-cycle voltage wave at which flashover occurred was governed merely by chance. These curves show that for a given electrode spacing and excitation voltage, power-arc follow-up is more likely to occur when current is flowing past the sparkover point. The explanation for this probably lies in the fact that current is immediately available for maintaining the power arc without having to overcome the inductance of the circuit. The curves show also that for a given electrode spacing, the possibility of power-arc follow-up is dependent upon the value of normal frequency excitation voltage.

During 66 of the tests oscillograms of voltage and current in the transmission line were obtained, from which could be determined the point on the 30-cycle voltage wave at which flashover occurred. Results of these tests showed that a high percentage of flashovers occurring near the 90-deg. point of the voltage wave resulted in power arcs. From a further analysis it was found that this grouping of tests near the 90-deg. point was very definite for tests in which current was flowing past the sparkover point, but when there was no current in the line the points were fairly well scattered.

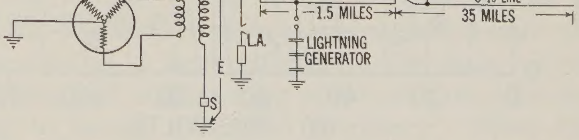

Fig. 1. Diagram of connections used in field flashover tests

Distance D between conductor and tower variable. With line off, switch A was open; with line on, switch A was closed

From "Experimental Studies of Arcing Faults on a 75-Kv. Transmission System," (**No. 31-102**) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

It is possible that on systems having large connected generating capacities carrying heavy loads, with the consequent immediate availability of large currents, the per cent of sparkovers developing into power arcs may be much higher than is indicated by these tests.

Characteristics of Power Arcs

In connection with relaying and short-circuit computations it is desirable to know, under certain fault conditions, something regarding the characteristics of power arcs. From the results of some 30 tests made under various conditions, some information has been obtained regarding the variations in arc resistance, wave shape, persistence, length, and voltage. In general, the arcs were formed in three types of circuits—resistive, capacitive, and inductive—at either 75- or 7.5 kv. and with initial currents varying respectively from 8 to 60 and from 200 to 800 amperes peak. Connections for these circuits are shown in Fig. 3. Measurements were made by means of a magnetic oscillograph through the use of shunts for current measurements and resistance potentiometers of the water-hose type having a resistance of approximately 500,000 ohms for voltage measurements.

It is known that the resistance of a d-c. arc is not constant, but is dependent principally upon the arc current and length. Because of the variation in an alternating current over a cycle, it is to be expected that the arc resistance would vary over a cycle, and if the length of the arc changed from cycle to cycle, a change in the limits of this cyclic variation should be noted for succeeding cycles.

Curves of Fig. 4 show that through a cycle, the resistance varies over a wide range, being high for low values of current and low for high currents. The minimum arc resistance for the cycle near the point of extinction of the arc (28th cycle) is larger than the corresponding value for the cycle near the start. This difference arises from the lengthening of the arc and the decrease in current. The curves in Fig. 5 illustrate this change in instantaneous resistance with respect to time, and in general show an increase with the passage of time until the arc was extinguished. In the early stages of the arc the increase in resistance is caused by the lengthening of the arc; as the resistance increases it becomes a larger percentage of the circuit impedance and limits the arc current. The decrease in arc current still further increases the resistance, so that finally the arc is extinguished. The curves described are for a test made in a resistive circuit and are of the same nature as those for the capacitive and inductive circuits.

The question as to the phase relation between the arc current and arc voltage frequently has arisen. Although the oscillograms indicate that for every test the arc current and voltage have simultaneous zeros, the apparent power factor of the arc may not be unity if the variations of arc current and voltage are not sinusoidal. An analysis of the oscillograms for the tests in which the arc current varied from 8 to 60 amperes peak showed that the apparent power factor of the arc varied from unity near the start to 0.75 near the point of extinction. For the high-current tests (200-800 amperes peak) the apparent power factor was practically unity.

Changes in wave shape of the arc current and arc voltage are attributable to the variation in arc resistance over a cycle. Near the start of the arc the resistance is not of sufficient magnitude to affect the current, but the arc voltage is affected by the variation in resistance and tends to become a square wave. Near the point of extinction of the arc, where the resistance is greatly increased, the current is greatly decreased and distorted and the voltage approaches in magnitude and wave shape the open-circuit voltage.

The records obtained when the arc was formed in the three types of circuits (resistive, capacitive, and

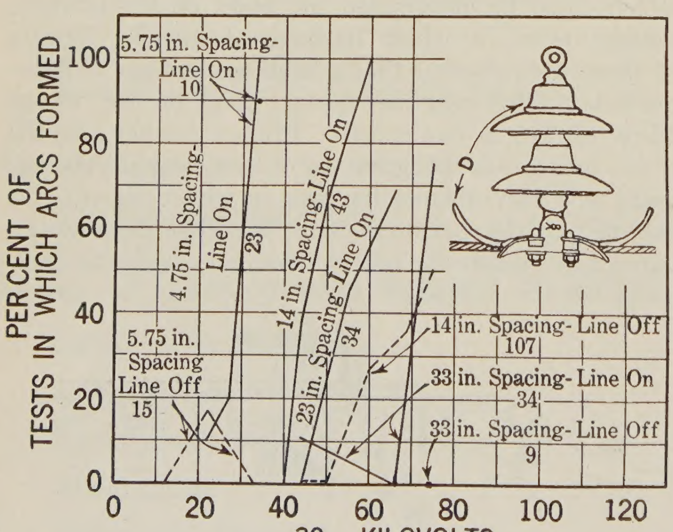

Fig. 2. Flashovers developing into power arcs

Tests made at various line voltages, with different electrode spacing D, and with and without the capacity effects of 35-mi. line. Numbers under spacing designation indicate the number of tests in each group

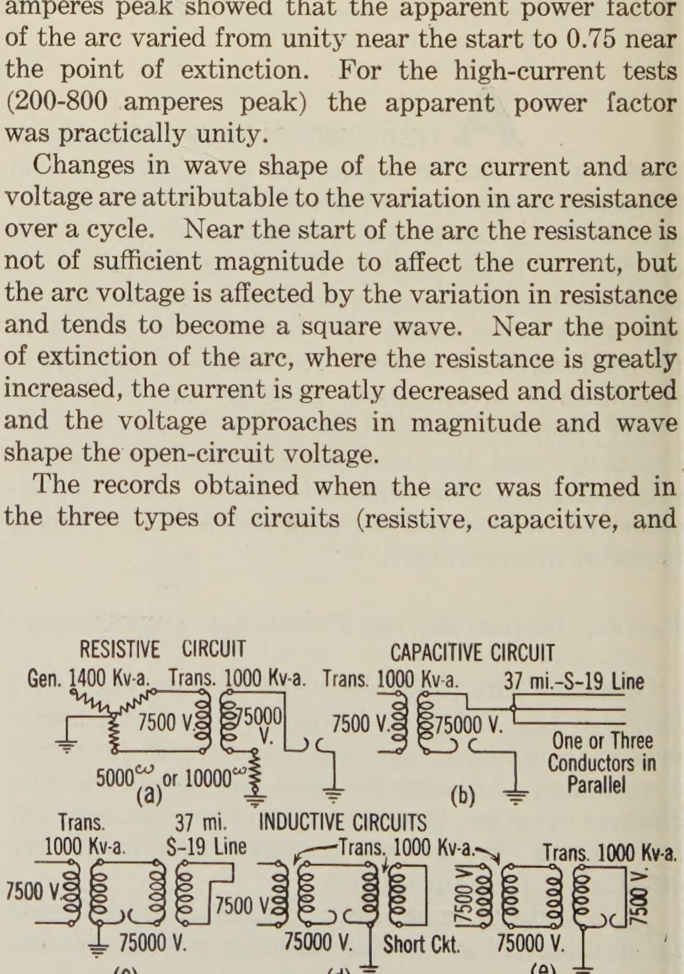

Fig. 3. Connections for tests of arc characteristics

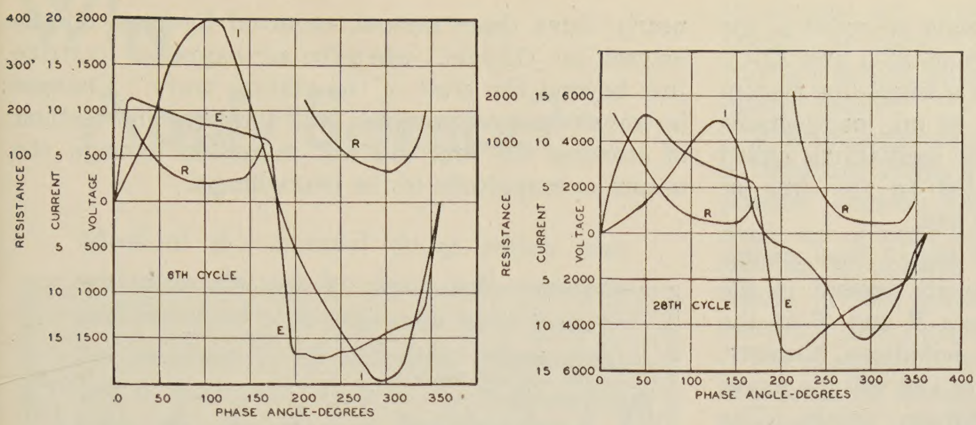

Fig. 4. Relations between arc voltage, current, and resistance for a cycle near the start of an arc and for a cycle near point of extinction

CORRECTION—In the "resistance" scaling of the center curve, "1000", should read "2000" and "2000" should read "3000"

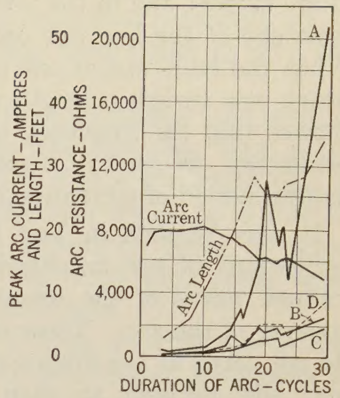

Fig. 5. Results of arc test in a resistive circuit

A—Instantaneous resistance for peak voltage
B—Instantaneous resistance for tail voltage
C—Instantaneous resistance for peak voltage
D—Ratio of peak current to peak voltage

inductive), indicate that only in the case of the capacitive circuit did the arc restrike following the first extinction at current zero. Although it was not possible to duplicate exactly the conditions of wind, wave shape, and current for these three types of circuits, apparently if arcs are formed under identical conditions in these three types of circuits, the capacitive arc will show the greatest tendency to persist because of its restriking after the first extinction. The explanation for the restriking of the capacitive arc lies in the fact that the charge trapped on the equivalent condenser in the circuit causes the voltage across the arc to rise to twice normal immediately following arc extinction.

A fairly accurate determination of the length of the arc was possible by combining the measurements from two motion picture cameras which were set up at right-angles to photograph the arc. Arc voltages which corresponded in time to the measurements of length were obtained from the oscillograms. It was found that if the peak voltage per foot of arc length were plotted against current, there was a very definite grouping of the points for currents above 100 amperes peak at 300 peak volts per foot of arc length. There was no definite grouping of the points for currents below 100 amperes peak.

Overvoltages Due to Arcing Grounds

Opinions vary rather widely as regards the maximum overvoltages which can be developed on an isolated-neutral transmission system at the time of an arcing ground, according to whether such opinions are based upon theoretical considerations, on laboratory tests, or upon limited operating data. From the tests on a part of the isolated-neutral transmission system of the Consumers Power Company information on the nature and magnitude of such overvoltages was sought.

In Fig. 6 is shown a schematic diagram of the 75-kv. three-phase system utilized. The transformers were connected either Δ/Δ or Y/Y with the low-voltage neutral grounded or isolated, and the length of line was varied up to 134 mi. Faults involving arcs to ground were produced on phase M conductor at different points on the line, which was open at the far ends. These faults were initiated in different ways and were made through both high- and low-external resistances. At the time of the fault the phase voltages to ground and the arc current were recorded on magnetic-type oscillographs as previously mentioned. Surge-voltage recorders were connected to the three phases at the generating end and at the open end of the transmission line to supplement oscillographic measurements of voltage.

The highest sound phase overvoltage recorded by the oscillographs in 64 arcing ground tests made on the isolated system was 2.8 times normal; the maximum surge-recorder measurement was 3.0 times normal. In every test the faulted phase voltage was less than the sound-phase voltage and in no case were the surge-recorder measurements more than 15 per cent higher than the corresponding oscillographic records. In a majority of the tests the maximum overvoltage occurred during the first cycle of the fault and was from 10 to 15 per cent higher on phase B which led the faulted phase voltage, than on lagging phase T. Average values of the highest overvoltages recorded during the fault for all the tests were 2.35 and 2.13 times normal for phases B and T respectively.

Oscillograms shown in Fig. 7 illustrate the nature of the transient changes at the time of a fault as they occurred in a large number of the tests. Both the striking and extinguishing of the arc take place according to normal (30-cycle) frequency. When the arc strikes, the faulted phase voltage is reduced to zero and a highly-damped standing wave follows the traveling wave set up on the faulted conductor. This standing wave is evidenced by oscillations in the wave

of arc current and in the voltage wave recorded at the open end of the line (see oscillograms 82-A and 82-C). When the fault was at one end of a single-line system which was varied in length up to 94 mi., oscillograms showed that the frequency of these oscillations, called oscillatory frequency, corresponded to the free or natural period of oscillation of the line.

It may be seen in Test 82 of Fig. 7 that similar oscillations of low amplitude also are present in the voltage waves of the sound phases *B* and *T* at the striking of the arc. These small oscillations, however, do not occur at the highest crest of the voltage waves and add nothing to their maximum values. The overvoltage is essentially a fundamental-frequency phenomenon and is made up of (1) a change in impressed voltage from that of line-to-neutral to that of line-to-line without going through an oscillation of appreciable amplitude, (2) a d-c. transient which shifts the zero of the normal-frequency wave, and (3) in some cases a harmonic of lower order. Surge recorders testified that no transients of higher magnitude were present. In the case of an unstable arcing ground, such as that shown in Test 71, the current restruck from zero usually every half-cycle, when the voltage was equal to or less than its normal crest value, and resulted in no building up of overvoltages.

A high-resistance arcing ground fault such as an intermittent tree ground, even if it persists for some time, was found to limit the shift of the system neutral and hence to tend to limit the magnitude of overvoltages produced. The highest measured overvoltages, nearly three times normal, occurred for tests on the longest line (134 mi.) when the arc happened to strike just beyond the crest of the voltage wave. Changes in transformer connections, fault location, and method of starting the arc, did not materially change the nature or magnitude of the overvoltages.

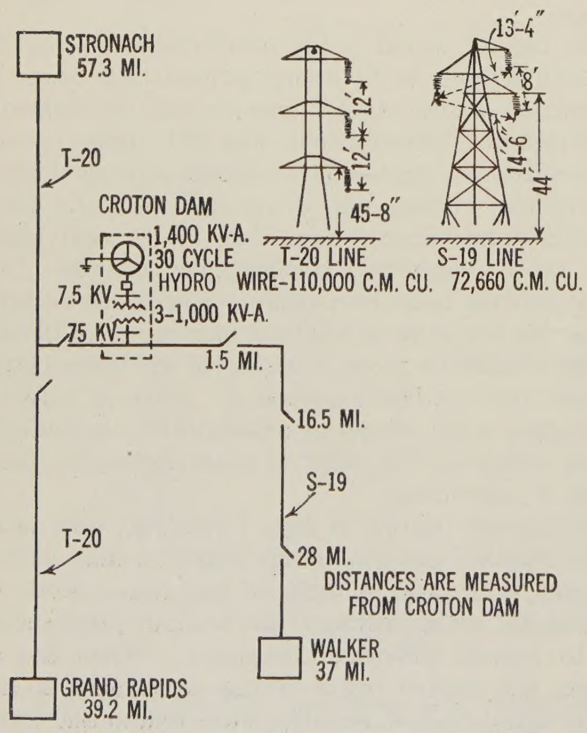

Fig. 6. Layout and configuration of test lines

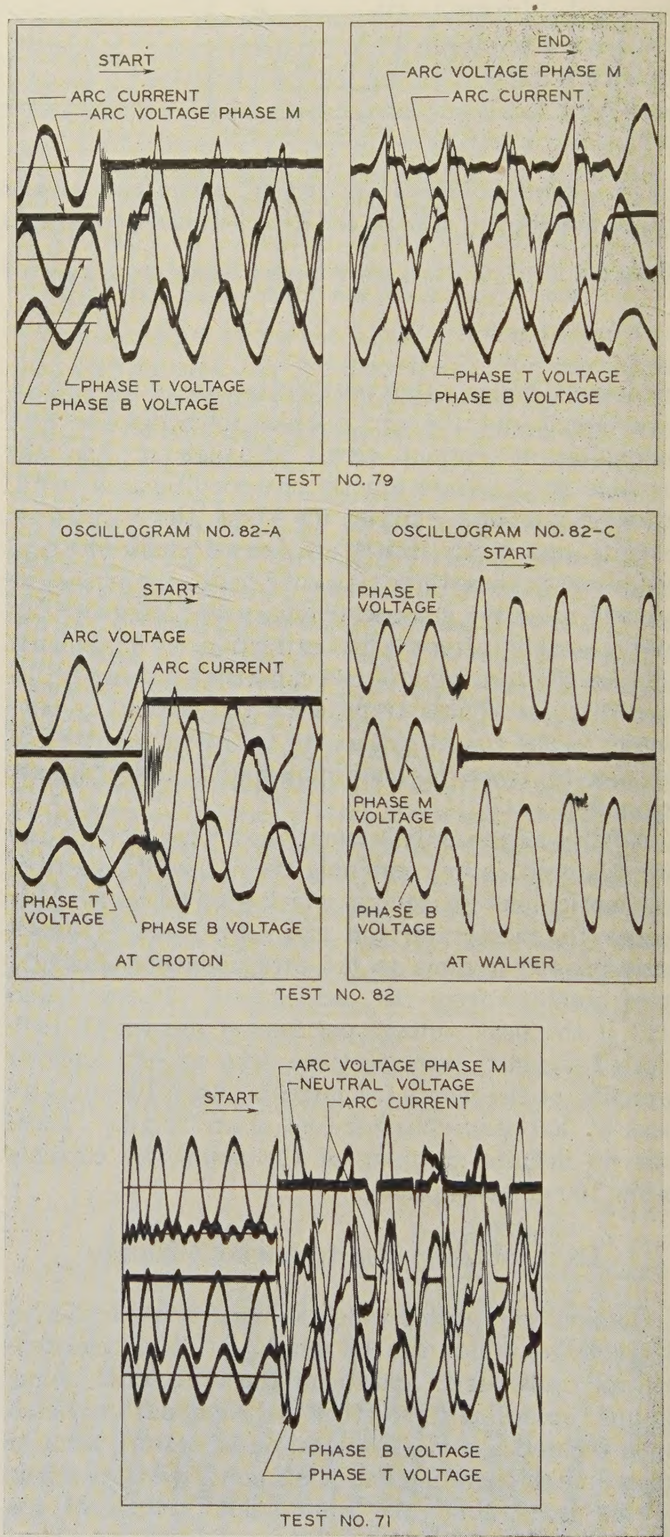

Fig. 7. Typical oscillograms resulting from arcing ground tests

Why Apply Science?

Most of the material things which man wishes to do can be done with certainty and repeated with assurance only through the application of scientific information. This is the fourth article of The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
H. E. HOWE   Editor, Industrial and Engineering Chemistry

HOW OTHER than through applied science could one discover why clean scab-free potatoes can be grown in some fields and not in others? It has been learned that the hydrogen-ion concentration of the soil is a determining factor, and simple means have been devised which enable an unscientific man to make the necessary tests, within limits, and choose soil of proper acidity to guarantee scab-free potatoes. A very small quantity of selenium in copper renders the copper less suitable for the transmission of electric impulses than if the copper were pure. Without science, how could such a small difference have been discovered? It is a further application of science to remove effectively the interfering selenium; and a still further utilization of science to find ways for employing the by-product selenium. It is another triumph of science that the use of selenium in certain types of glass has given us spectroscopic red glasses so necessary for signal lamps which must show red under all circumstances and to all eyes.

When, again through applied science, it became known how to use chlorine for bleaching textiles, it was not realized how quickly the chlorine will do its work under controlled conditions. Thanks again are due to science for learning these conditions and for determining what took place, with the result that under some circumstances thorough bleaching can be done in 45 seconds without detriment to the fiber.

There are uncounted examples of similar occurrences in industry, where a lack of uniformity in finished products would be immediately noticeable without the control possible only through applied science. Small differences in time, in temperature, in velocity, and in concentration, make for the difference between success and failure. It is science that determines what these limitations are, and again it is science that makes possible an adherence to a prescribed procedure which through experimentation has been found to give the desired results.

When it is remembered that, as Huxley said, science is organized common sense, the question "why apply science" answers itself. The life of a normal man is made up of little conquests with which he always is striving to achieve some objective. Most of these efforts involve materials, and it is with these same materials that science concerns itself.

The chances for having a thing do what one wishes are increased immeasurably as accurate knowledge is acquired, not only of what takes place, but of just how and why events occur as they do. When such details are known, happenings often can be controlled to a nicety. It is this control of natural processes that applied science makes possible; without such control there is loss, disappointment, and failure.

Fruitful application of science by no means is confined to industry. It has its most useful work today in the field of health and disease. There is perhaps no organism so delicately balanced as the human body; the mere difference of where an atom is placed in a molecule leads to so great a divergence in the characteristics of that molecule as profoundly to affect the human body. Adrenalin exists in two forms; one of these the mirror image of the other. One molecule may be said to be left-handed and the other right-handed. One has fifty times the potency of the other. Some of our best known germicides have been devised with a similar knowledge of the effect of small differences. Hexylresorcinol is much more useful than would be a compound with five or one with seven of these groups.

Other examples of comparatively small differences are found in carbon monoxide—a subtle, deadly poison—and carbon dioxide—a highly useful industrious gas. The difference is a single atom of oxygen. Mercury compounds show similar differences between the one use as a disinfectant and the other as a medicine. So long as such small differences are vastly important there is obvious need for the application of science, for without science these differences cannot be determined and the resulting information utilized.

Through its thousands of years, the race has learned much by bitter experience. However, even in the oldest industries, like bread making, tanning, and brick making, things have occurred beyond control until science stepped in to determine cause and effect, and to indicate conditions under which control may be maintained and success thereby assured. Most of the material things which man wishes to do can be done with certainty and repeated with assurance only when based upon scientific information. Progress in the oldest arts as well as in the newest can be measured accurately by the extent to which science is applied.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Electric Analogs for Difficult Problems

When the mathematical solution of a problem is so difficult as to be impracticable it sometimes is possible to obtain the desired answer from the behavior of an analogous electric circuit. This article presents an analog of "coulomb friction," and demonstrates the application of this analog to the previously unsolved problem of the torsional-vibration damper.

By
H. H. SKILLING
Associate A. I. E. E.

*Stanford University
California

SOLUTION of the equation of motion for the torsional-vibration damper represents one of the mathematical problems which is extremely difficult to solve. Almost endless complications are involved on account of the peculiar combination of vibratory motion and friction which the problem contains. An approximate solution can be arrived at by introducing several assumptions, but this is not entirely satisfactory; in the more intricate cases, approximate solutions are of no value at all. In order to predict the effectiveness of new designs, mechanical models sometimes are built and tested. Difficulty often is experienced, however, in the construction of these models, and in addition, the results obtained have been found to be somewhat uncertain.

In this article is proposed a method of solution wherein electric analogs are set up for the various types of mechanical motion involved. An electric circuit can then be set up with constants analogous to the mechanical characteristics of the apparatus being studied. The principal advantage in treating the problem in this manner is in dealing with a system easily put together and altered, and with quantities easily metered. Although the analogous method in general is not new, difficulty has been experienced previously in representing mechanical friction electrically. In the present investigation this obstacle has been overcome by the use of gaseous conduction tubes.

The torsional-vibration damper is in effect a flywheel that fits loosely on a shaft. A common application is on the crank-shaft of a Diesel engine, where there is danger of torsional stress in the shaft becoming extremely large because the natural frequency of oscillation of the shaft may be the same as the firing frequency of the cylinders. The damper flywheel is placed on the shaft at the point where torsional vibration is greatest; it is not keyed fast but turns with the shaft because of the friction between the two. When rapid torsional vibration of the shaft exists, the friction force is not great enough to accelerate the flywheel as rapidly as the shaft; hence the shaft slips within the flywheel and in so doing dissipates sufficient energy to prevent resonant oscillation of the shaft. In actual design, the damper although simple is not so elementary as this account has indicated. A detailed description may be found in a paper by Den Hartog and Ormondroyd (*A. S. M. E. Trans.*, Vol. APM-52-13, p. 133) which also treats its action by an approximate mathematical solution.

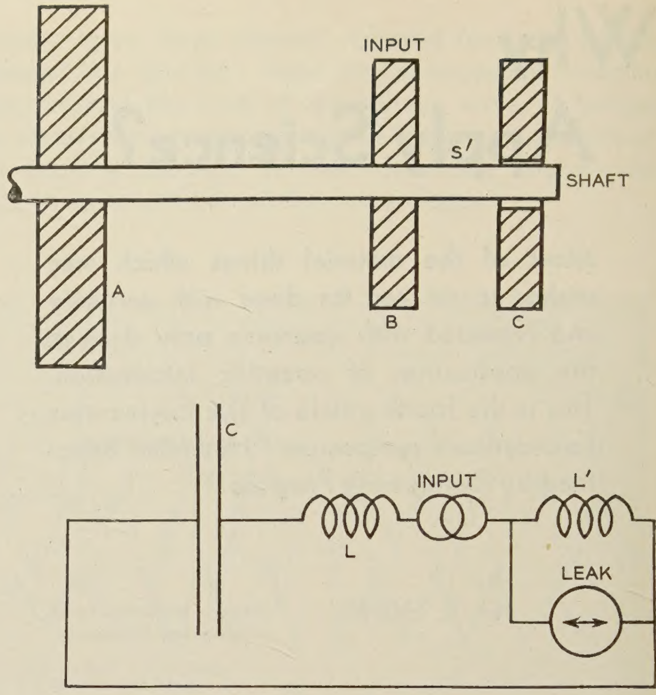

Fig. 1. (Above) mechanical system schematically representing the Diesel engine; (below) the electric analog of this mechanical system

With ordinary dry friction—so-called "coulomb friction"—which is involved in the torsional-vibration damper, the frictional force depends upon the nature of the rubbing surfaces; also upon the force holding them together, but not upon velocity. An electric analog for this application must therefore produce a constant voltage drop, variable at will but independent of the amount of current flowing.

A mechanical system which is the practical equivalent of a Diesel engine may be seen in Fig. 1. The main flywheel is shown at A; moment of inertia of the pistons, cranks, and other moving parts is represented by another flywheel B; the damper flywheel which fits

*Written especially for ELECTRICAL ENGINEERING and the A. I. E. E. TRANSACTIONS based upon research work carried on by the author at Massachusetts Institute of Technology, during 1929-'30. *Not published in pamphlet form.*

loosely on the shaft is shown at C. Input torque from the cylinders, which may be considered as a steady torque with a superposed alternating torque, enters the system at the pistons. Any load on the engine will be applied to the left of the main flywheel.

Table I—Mechanical-Electrical Analogies

Mechanical quantity	Electrical quantity
Torque	Voltage
Velocity (angular)	Current
Displacement (angular)	Charge
Moment of inertia	Inductance
Elastance (torsional)	Elastance
Mechanical hysteresis	Resistance

The electrical analogy to this mechanical arrangement is shown also in Fig. 1 where, with the exception of friction between the shaft and the damper flywheel, the electrical quantities used are as shown in Table I. Analogous to the shaft is condenser C; analogous to the piston flywheel B is inductance L. These cooperate to form the oscillating system, since the main flywheel is so large that for the present it can be considered infinite and therefore impassable by any vibrations. The damper flywheel C is represented by the inductance L, but because of its looseness on the shaft a shunt must be connected around the inductance to make the analogy complete. In this shunt is the apparatus which, to be analogous to friction of the flywheel on the shaft, must prevent current from flowing until a certain voltage is reached, and then permit current to pass without any further increase of voltage.

The peculiar property of constant voltage drop is possessed by a mercury arc; it is also characteristic of glow discharge under special conditions. For this investigation raytheon gaseous conduction tubes were employed. Two tubes were used, one to pass current in each direction; the voltage drop in the tubes as they were connected in this case was 85 volts independent of current. In series with each tube was a source of potential which either added to or subtracted from the 85-volt tube drop depending upon other conditions. For the input to the circuit an alternator was used the speed and voltage of which could be varied over an extremely wide range; its resistance, together with that of the rest of the system, was small. For mechanical hysteresis losses in the elastic parts, and for any viscous friction that may exist, resistance is sufficiently analogous to permit its use.

The validity of the complete analogy may be seen from the differential equations of the two systems which are adapted from Den Hartog. For the mechanical system,

$$I \frac{d^2 \alpha}{d t^2} + I' \frac{d^2 \alpha}{d t^2} + k \alpha = M \sin \omega t$$

when the damper flywheel is not slipping, and

$$I \frac{d^2 \alpha}{d t^2} + k \alpha \pm T = M \sin \omega t$$

when this flywheel is slipping.

I = moment of inertia of system being damped
I' = moment of inertia of damper flywheel
k = elastance of shaft
α = flywheel displacement from neutral
$M \sin \omega t$ = input torque as a function of time

The analogous electrical equations, when the shunt is not working and when it is, are respectively,

$$L \frac{d^2 q}{d t^2} + L' \frac{d^2 q}{d t^2} + \frac{1}{C} q = e \sin \omega t$$

$$L \frac{d^2 q}{d t^2} + \frac{1}{C} q \pm v = e \sin \omega t$$

All terms are well known except v, the voltage drop in the leak, which is added or subtracted depending upon the direction of the current. The analogy of corresponding terms, displacement, and charge, for example, may be seen to agree with Table I.

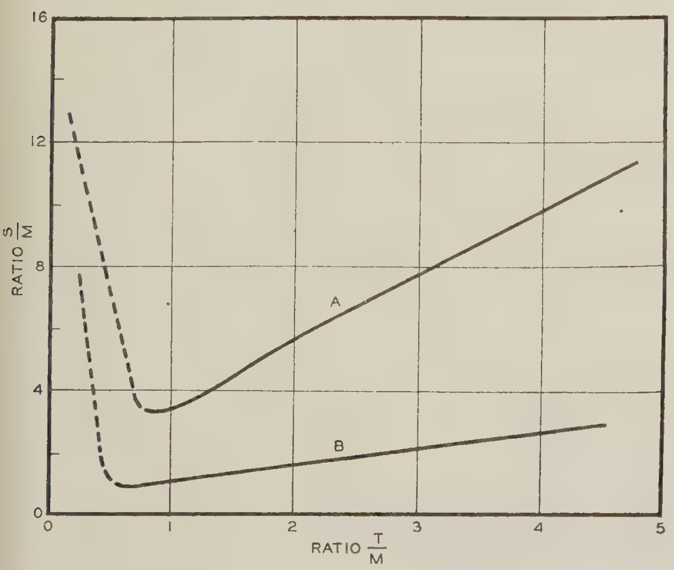

Fig. 2. Performance curves for the torsional-vibration damper as determined by electrical analogy. (A) With rigid damper shaft; (B) with elastic damper shaft

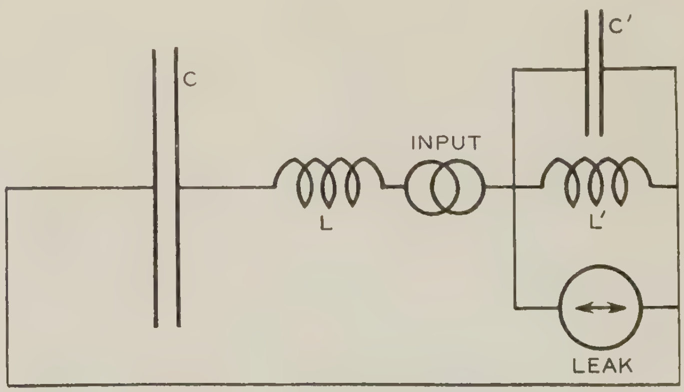

Fig. 3. Electric analog of the torsional-vibration damper with elastic damper shaft. Compare Fig. 1

The purpose of making a detailed study of damper performance, whether by mathematics, model, or analogy, is to determine whether a particular damper is so proportioned as to prevent dangerous stresses in the shaft. Momentary stresses in a shaft are exceedingly difficult to measure, but the analogous voltages across the condenser in the electric circuit may be read quite easily on a crest-reading voltmeter; thus for any given combination of quantities and dimensions an indication of maximum stress is obtained immediately by simply reading that meter.

The crest voltage of condenser C (Fig. 1) is analogous to the maximum torque in the shaft and will be designated by S; analogous to the torque required to slip the shaft inside the damper flywheel, is the voltage drop in the leak which will be denoted by T. Results of a study by such analogy may be plotted showing S as a function of T, where curves similar to those of Fig. 2 will be obtained. If the value of S at the lowest point of the curve represents a safe stress, the damper is large enough to be useful; the value of T corresponding to this minimum value of S gives the optimum adjustment for tightness of the damper flywheel.

To avoid changing back and forth from mechanical to electrical units, it is well to avoid absolute values of quantities. Relative values need not be so transformed. Let M be the amplitude of the alternating input torque; instead of plotting S as a function of T, S/M may be plotted as a function of T/M. This scheme involves neither volts nor foot-pounds but only ratios, the ratio of voltage to voltage being of course numerically equal to the analogous ratio of torque to torque. The scale of the electrical model is equally unrestricted; only the proper ratios between parts need be specified. The frequency of the input voltage is of course the frequency causing the most severe stress; in the simple mechanical system the crucial stress will occur when the frequency of firing is the same as the natural frequency of the vibrating system.

As a typical example, assume a damper with moment of inertia of the damper flywheel equal to the moment of inertia of the system being damped. In the analog any convenient capacitance and inductance may be used to represent C and L (Fig. 1), but they must be resonant at some frequency attainable by the alternator used for *input*. The inductance L' equal to L is then added, and the vacuum-tube leak is connected across L'. The input voltage is adjusted to any convenient value, and the voltage drop in the leak circuit made comparatively large (for instance, 15 volts input and 85 volts drop in the leak). Now, as the frequency of the input voltage is varied, the crest voltage across condenser C will rise to a maximum and then decline. The maximum value of this voltage (in this particular case about 208 volts) is analogous to the maximum torque in the engine shaft. Dividing this by the maximum value of the input voltage, (about 21.2 volts) and the result S/M is about 9.8; divide the 85-volt drop also by 21.2 and the quotient, which is 4, is the value of T/M. By varying the leak and input voltages, enough points can be determined to give curve A of Fig. 2. This curve gives the whole story of the operation for this particular damper. Moreover, it gives the entire story of operation for all dampers having the same moment of inertia as has the system being damped. In present practise, however, a damper has from one-fifth to one-tenth the amount of inertia of the system being damped, and S/M is proportionately larger.

So far, the damper has been considered as being applied to the simplest possible vibrating system. This simple system may be solved mathematically, although with some difficulty if approximations are avoided. Accordingly, this case was used as a general check on the method, and the results were compared with Den Hartog's computed values; agreement was so close as to be within the limits of experimental error.

With the more complicated systems, however, solution by analogy is of far greater value. When the elastance of that part of the shaft labelled S' (Fig. 1) is considered, a mathematical solution is out of the question; in the analog a condenser of the proper size is simply shunted around L', and the solution is as simple as before. The study of this circuit disclosed an interesting and important relationship that previously was not recognized. As it is a typical analog, it will be used as a further example of the application of the method.

The circuit used with C' representing the elastance of the damper-shaft is shown in Fig. 3. The elastance of condenser C' must bear the same proportion to condenser C as elastance of the damper-shaft does to the main shaft. Now as the input frequency is varied, the voltage measured across C no longer has one maximum, but three. The reason for this is apparent from the diagram, since there are now two resonant parts of the circuit, consisting of (1) C and L and (2) C' and L'. At some definite frequency the reactance through C and L in series is zero; at two additional frequencies the reactance of the complete circuit is zero. However, if the natural frequency of C' and L' is the same as that for C and L, when the reactance through C and L is zero, the reactance through C' and L' is infinite; thus the circuit current under these conditions is small and one maximum eliminated. The other two maxima, one falling at a higher and one at a lower frequency, must be prevented from becoming serious by the action of the leak.

Experiments with this second analog showed that the damper is much more effective with an elastic damper-shaft than it is with a rigid shaft as in the first case. When the damper flywheel has one-fifth the moment of inertia of the system being damped, and when the damper-shaft is one-fifth as stiff as the main shaft, the analog method gives results as shown in curve B, Fig. 2. To make due allowance for the light weight of the damper, all ordinates have been multiplied by the ratio of moments of inertia (one-fifth); this makes the

curves comparable to those of Den Hartog and Ormondroyd if a factor of $1/\pi$ is introduced into the vertical scale.

Since the primary purpose of this article is to point out the merits of the electrical means of solution, no particular attention is given to the mechanical merits of this new design of damper. Certain relationships were discovered by study of the analog, however, which seem worthy of mention. The "elastic damper-shaft" is not in the nature of a spring, for a shaft one-fifth to one-tenth as rigid as the main shaft of a Diesel engine is needed. The torque on the damper-shaft never can exceed T, the slip torque of the damper, and the shaft may be designed accordingly. The smaller the damper, the more effective will be a proper damper-shaft in improving its performance.

In conclusion, the principal advantages to be gained by the use of the electric analog are that (1) it shows the extent to which an approximate mathematical solution may be trusted, and (2) it offers a new method of approach to designers of dampers and other frictional devices. It is particularly useful in the study of new designs and at present there appears no limit to the possible applications of the method.

Power Equipment at KDKA's New Station

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Power for the two new high-power radio transmitters housed in KDKA's new quarters is obtained from a special 1,500-kva. outdoor substation. Included in the power equipment is a twelve-phase, 900-kw., 30-kv., mercury-cathode tube rectifier, the largest of its type yet built for radio.

THE NEW KDKA radio station at Saxonburg, Pa., has been designed not only for high-power broadcasting but also for experimental work dealing with the development of super-power transmitters. Two complete and independent high-power transmitters are involved, both being housed in the same building. One of these normally is operated at 980 kc. using the familiar signature KDKA, while the other is planned for higher frequency work. A station of this nature quite obviously required equipment considerably larger than that found in any ordinary broadcasting station. This is especially true of the power supply apparatus, among which the larger of the two main rectifiers is the largest high voltage unit ever constructed for such use.

Power is obtained from a 1,500-kva. outdoor substation about 700 ft. distant from the station building. This substation is fed from a 25-kv. loop circuit with relays and breakers so arranged that in case of trouble any faulty portion of the loop will be disconnected automatically without service interruptions on other portions. From the low voltage side of the transformer bank, power is carried to the station building over two three-phase 2.5-kv. armored cables laid directly in the ground.

Main Rectifiers

Both main rectifiers are of the polyphase mercury cathode type and operate directly from the 2.3-kv. three-phase supply. The larger rectifier has a rating of 900 kw. at 30 kv., and employs six 190-kva. single-phase transformers to provide the proper voltage and phase relations for twelve-phase rectification. (See Fig. 1.) Special connections are employed on the supply side of these transformers, since a Y-connection with floating neutral is undesirable for rectifier service.

Three of the transformers are connected in delta and the other three are carried across this delta from each apex to the midpoint of the opposite side, a tapped primary winding being used to give the required voltage relations. All six transformers are provided with two separate high voltage windings; these are connected to form four Y's, each of which is connected to one multi-anode mercury cathode rectifier. The d-c. outputs of the four tubes are connected in series so that while rectification takes place in four three-phase units, the result is the same as though a single high voltage multi-anode tube of twelve phases were employed. Connecting the outputs of the four tubes in series in this manner also requires only a moderate

Based upon "Power Equipment at New KDKA Station" (No. 31-67) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

inverse peak voltage per tube in spite of the unusually high d-c. voltage developed.

The smaller, or 450-kw. 20-kv. rectifier, is similar to the larger one except that only three single-phase transformers are employed thus providing for six-phase rather than twelve-phase rectification. In both cases untuned filter circuits consisting of large iron-cored reactors and banks of high voltage condensers are employed to smooth the rectifier output.

Adjustment of the d-c. voltages developed by the rectifiers is accomplished by means of three-phase induction regulators designed to operate over a range of 100 per cent above and below line potential. With this arrangement the applied a-c. potential thus may be varied from 0 to 4.6 kv. Both regulators are motor operated and are remotely controlled from the operating room. The output of both rectifiers is controlled by air-break contactors similar to those used in mine hoist control, and which operate directly in the 2.3-kv. supply circuit. Both a-c. and d-c. overload relays are provided to shut down the equipment in the event of trouble necessitating the removal of plate voltage. For safety to operators the contactor control circuits are interlocked through switches on doors giving access to high voltage circuits. An oil circuit breaker manually operated from the main switchboard also is provided for each rectifier.

Mercury Cathode Tubes

Tubes used in the main rectifier are of the glass envelope mercury cathode type (see Fig. 2) and are somewhat similar to ones formerly used for operating d-c. series arc light circuits. The tubes are fully immersed in oil, each being housed in a separate tank and mounted in a cradle by means of which it can be removed readily. (See Fig. 3.) All necessary connections are made when the cradle slides into place, thus permitting tube changes to be made conveniently. For interchangeability, tubes of the same rating are used in both main rectifiers.

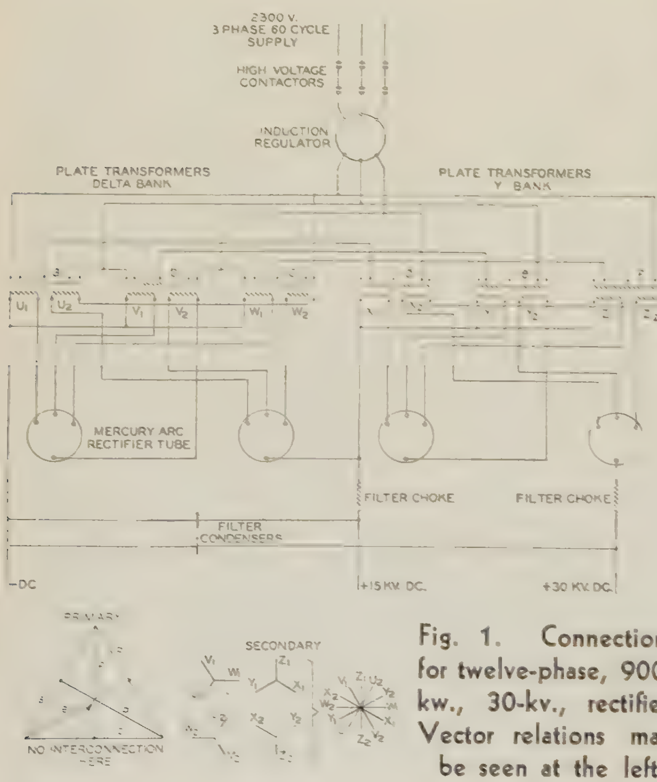

Fig. 1. Connections for twelve-phase, 900-kw., 30-kv., rectifier. Vector relations may be seen at the left

In addition to the three main anodes, the tubes are equipped with two small sustaining arc anodes, and one starting mercury anode. Automatic tilting mechanisms controlled from a push-button station are provided for starting the sustaining arcs. This mechanism functions in from one to two seconds, after which full operating plate potential may be applied immediately. Very little energy, about 120 watts per tube, is required to operate the sustaining arcs. This is small compared to the filament heating requirements of a filament type tube rectifier for furnishing the same power output. While not commonly employed for radio power apparatus, nevertheless mercury-cathode rectifier tubes have desirable characteristics particularly in installations such as these where the use of filament tubes would be prohibitive on account of the number required.

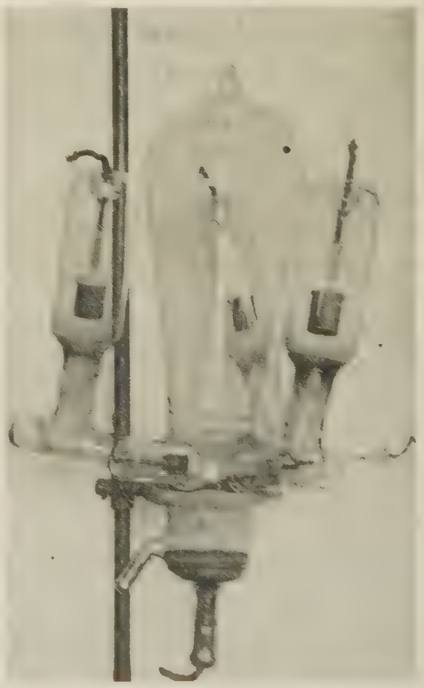

Fig. 2. High voltage mercury-cathode rectifier tube

Filament Heating Generators

In all but very small telephone transmitters, direct current is required for heating vacuum tube filaments. To meet the requirements of both transmitters, a total of six motor-generators were installed, three normally being assigned to the 980-kc. set and two to the higher frequency outfit, leaving one in reserve. A view of

one of these generators is shown in Fig. 4. Each generator is rated conservatively at 1,000 amperes 40 volts d-c., and is driven by a 75-hp. line-start motor operating directly from the 2.3-kv. station supply. To reduce commutator noise to a sufficiently low value so that no filter is required, the design of these generators include special features such as large air gaps, skewed slots and a large number of commutator segments. As an added refinement each unit is mounted on a concrete base and the whole assembly supported on a cork pad to minimize vibration.

Interlocks between the tube cooling-water relays and

Fig. 3. Tanks housing main rectifier tubes

the filament generator field circuit provide low-water protection. A special starting resistance in the field circuit also is interlocked with the filament excitation control which prevents a damaging current rush when voltage first is applied to the tube filaments since these possess only about ten per cent of normal operating resistance when cold.

Besides the six filament-heating motor-generator units, four 10-kw. 3-kv. d-c. generators are employed to furnish plate circuit energy for the smaller intermediate amplifiers and also to provide grid bias voltages. These generators have two 1,500-volt commutators connected in series, and are provided with filters to reduce commutator ripple.

All four generators have one terminal permanently connected to the filament bus or ground circuit. This is possible since the change of polarity necessary when changing from plate to grid service can be accomplished by simply reversing the excitation. To simplify interchange of connections, a special bar and plug board without cables is used. On the rear of this board are mounted vertical and horizontal interconnecting bars to which the transmitter circuits and generator termi-

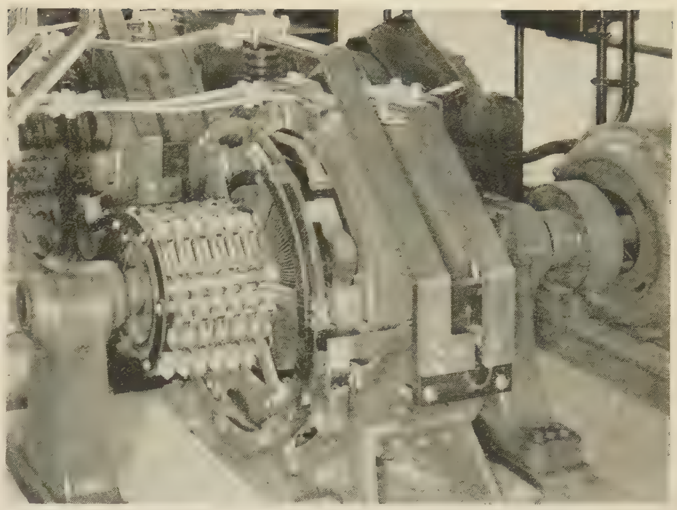

Fig. 4. One of the six 1,000-ampere 40-volt generators used for tube filament heating purposes

nals are connected. Any desired combination of connections may be effected simply by plugging through the front of the board to the connecting bars. The dead front construction virtually eliminates live plug danger.

Control Equipment

The entire control scheme for the power equipment has been arranged in so far as possible so that in the normal course of operation the operator need not leave his position in the main transmitter room. Relays and interlocking mechanisms are provided so that none but the proper sequence of operation is possible. Signal lights adjacent to push-buttons indicate the state of circuit relays and response of contactors being controlled. Suitable meters inform the operator of the operating conditions of all important transmitter power circuits.

All control circuits and meter leads from the outdoor substation to the transmitter building are installed underground to prevent possible high frequency effects. To avoid an otherwise unnecessary 110-volt battery and resulting high voltage drop between the transmitter room and substation, special 400-volt coils were used in the circuit breakers thus permitting their operation from the station "B" battery.

Adequate control of the various intermediate amplifier stages requires the opening and closing under load of 3-kv. d-c. circuits. For this purpose a special 2-ampere contactor was developed having two air breaks in series both equipped with magnetic arc blowouts. The contactor employs a special mechanism to obtain rapid contact travel and wide openings.

Other Apparatus

Besides the major power units which have been described many conventional pieces of equipment are used such as exciters, tube-cooling-water pumps,

blowers, battery chargers, and station service transformers for the small power units, lights, and heating. For simplicity of control and convenience in starting, all motors including the 75-hp. units which drive the filament generators, are of the line-start type.

Although one battery will suffice for plate or "B" service, since by the employment of suitable filters it can be charged readily while in use, two filament batteries are advisable because of the difficulty of eliminating hum from heavy-current charging apparatus. Each of these should be capable of handling the entire load for one day. Accordingly, two six-cell, 1,600-ampere-hour storage batteries are furnished for the filament supply of the audio and synchronizing equipment in addition to the previously mentioned 400-volt "B" battery used for plate supply for small tubes. These large batteries also supply essential indicating lamps for the substation circuit breaker control, which require continuous illumination in the event of power failure.

In many broadcasting stations the tube cooling water is cooled in turn by a system of radiators and blowers. At the KDKA station site an opportunity to reduce the investment in cooling equipment was presented by the natural high level of ground water. Accordingly, a small pond was excavated from which sufficient water is obtained for cooling the tube cooling water by means of heat interchangers.

While commercial broadcasting stations as yet do not require equipment as large as that installed in KDKA's new plant, actual construction and use of such apparatus is necessary before the development of commercial high-power stations can be carried out. It is hoped that data can be obtained which will be of value not only in the specialized field of radio engineering but also to electrical science as a whole.

Reactance of Lines With Ground Return

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Charts have been prepared which make possible the fairly accurate determination of the resistance and reactance of the earth return circuit. These values, together with the usual line and ground wire self-inductances, may be inserted in a simple formula to determine the positive or zero-phase-sequence impedance of the complete circuit.

AN ACCURATE knowledge of the zero-phase-sequence impedance of transmission lines is necessary for the successful analysis of current flow during fault conditions. This factor is becoming increasingly important, because the faults which must be considered generally are those involving grounds; the use of the symmetrical-component method greatly simplifies their calculation. The constant increase in size of electric power systems, and in demand for reliability in service, necessitates an application of suitable relays determined largely upon knowledge of current flow during fault conditions. Therefore it is becoming increasingly important that the value of zero-phase-sequence reactance be accurately known. The zero-phase-sequence reactance of transmission lines is the reactance of the three line conductors in parallel with a ground return. The two main problems in the determination of this quantity are the mathematical analysis of the circuit and the determination of the ground return impedance.

Equations have been developed for the impedance of a circuit consisting of any number of line wires in parallel and a return path through ground alone or through ground and any number of ground wires in parallel. The application of these equations, however, is contingent upon a knowledge of the impedance of a single conductor with ground return. The impedance of such a circuit varies with several factors, chief of which is the distribution of the current in the return path below the surface of the earth. While this is largely dependent upon soil conditions, it obviously will vary with the locality and terrain. Hence, field tests have been made to obtain experimental data to use in predicting ground impedance, and to check the theoretical analysis.

From "Reactance of Transmission Lines with Ground Return" (No. 31-64) presented at the A.I.E.E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

Circuit Analysis

The analysis of the circuit is very simple although it involves such factors as the self-inductance of the earth path and the mutual inductance between a wire and the earth, which usually have been considered as fictitious quantities. By proper manipulation, however, the equations can be made to take on a real and definite form. For the analysis as given here it is assumed that the line wires are transposed so that the same current flows in each of the conductors. It is assumed also that the spread of the current in the earth is such that its mutual effect on all the line conductors or ground wires is the same within the usual horizontal spread of line conductors. Tests show that the error from this source is small.

Consider the circuit shown in Fig. 1. The impedance of such a circuit in this analysis is defined as the ratio of the applied voltage, E_{mn}, to the total current I. The current flows from the generator out along the line wires to the point of fault and back to the generator through the ground and ground wires in parallel. The effect of the current in the ground wire is simulated by a pseudo conductor imbedded in the earth and assumed to have a self-inductance of its own and a mutual reactance with the real conductors of the circuit. The depth of this assumed conductor below the surface of the earth, and its effective diameter, are not of interest for this analysis.

Starting from the generator, the voltage of the circuit is made up of the voltage drop from the generator through the ground to the point of fault and the voltage drop along one of the line conductors from the point of fault back to the generator. The voltage drop in any conductor of a circuit is made up of the voltage drop produced by the current in the conductor and its own self-inductance, and the voltage drop induced in the conductor by the current in other conductors through the mutual inductance. This may be written in the form of an equation; unfortunately, however, such an equation would contain the self-inductance involving the earth. This usually is said to be impossible of separate determination. If this self-inductance is combined with the mutual inductance between the earth and the line wire, or ground wire, reactance quantities are obtained which are real and which can be determined by measurement.

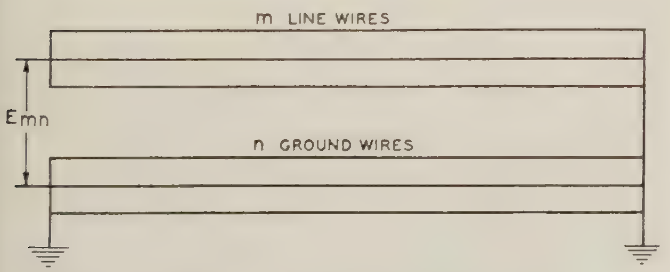

Fig. 1. Fundamental circuit of line wires, ground wires, and ground

of the conductor itself and does not depend in any way upon other conductors in the neighborhood. For mutual inductance another factor of course is required. If the current returns through the other conductor, the voltage drop in the first conductor is $I\,(L - M)$. This quantity $(L - M)$ usually is known as reactance. It can be determined by test or calculations either for a one-way conductor of a circuit alone or for both in series.

By the proper combination of resistances, reactances, and mutual inductances, the following expression for total circuit impedance can be developed:

$$\frac{E_{mn}}{I} = Z_{mn} = Z_{wg} - \frac{I_o}{I} M_{ow} - \frac{m-1}{2\,m} Z_{ww} \qquad (1)$$

where

$$M_{ow} = \frac{Z_{wg} + Z_{og} - Z_{ow}}{2} \qquad (2)$$

and

E_{mn} = circuit voltage
I = current as indicated by subscripts. Lack of subscript indicates total current
Z = impedance as indicated by subscripts
M = mutual impedance, as indicated by subscripts
m = number of line wires
n = number of ground wires
g = subscript indicating ground
o = subscript indicating ground wire
w = subscript indicating line wire.

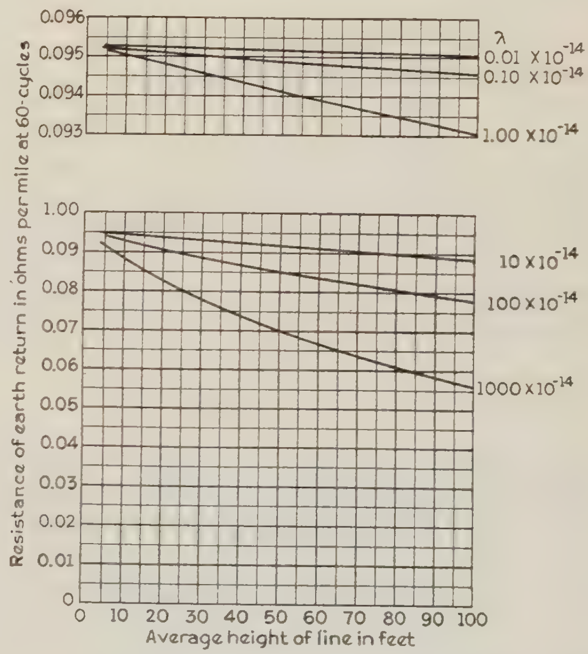

Fig. 2. Resistance of the return path through the earth for different values of earth conductivity λ and height of line

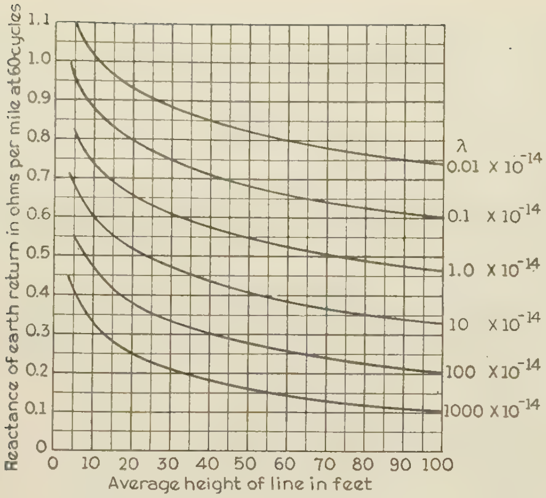

Fig. 3. Reactance of the return path through the earth for different values of earth conductivity λ and height of line

The zero-phase-sequence impedance enters into the calculations of ground fault currents as a quantity which operates on the zero-phase-sequence current. This current is equal and in the same direction in all three line wires and is one-third of the ground fault current. Accordingly the zero-phase-sequence impedance of a transmission line is the quantity obtained by multiplying by three the value of impedance given in equation (1).

The equations for the current in the ground wires may be developed from the fact that the over-all voltage drop from the generator through the ground to the point of fault outside the earth, and along the ground wire to the point of fault must be equal. The resulting equation is

$$\frac{I_o}{I} = \frac{M_{ow}}{Z_{og} - \dfrac{n-1}{2n} Z_{oo}} \tag{3}$$

To check the analysis field tests were made on four power systems facilitated by the use of a test wire parallel to the transmission circuit. These tests were made both with and without a ground wire and definitely indicate that the analysis is correct within a few per cent in all cases.

Ground Return Impedance

The successful application of the mathematical analysis depends upon a predetermination of the ground return impedance. The main problem in the calculation of ground fault current and the division of the return current between the ground wires and ground is the predetermination of the impedance of the fundamental circuit consisting of the conductor with ground return.

For many years it was customary to consider the earth as a perfectly conducting plane. All the reactance was assigned to the conductor and the corresponding distance to the "neutral plane" was calculated. This gave effective conductor heights up to several thousand feet and a wide variation was found, so that no good method of predicting the impedance of the circuit could be built up.

The calculation of the impedance of the fundamental circuit made up of a conductor with ground return requires a study of the distribution of the current in the ground. A solution to this problem has been given by Carson in the *Bell System Technical Journal*, October 1926. With some modification the expression developed by Carson states that the total impedance of the circuit equals the resistance of the conductor plus the reactance of the conductor plus the impedance of the ground return. The reactance of the conductor is calculated as if the return conductor were below the surface of the ground a distance equal to the height of the conductor. In other words, it is the one-way reactance of the conductor with image return.

The impedance of the earth Z_g in the solution worked out by Carson depends upon the conductivity of the earth, the distance from a conductor to its image, and the frequency. From these variables and an additional

Table I—Test Values of Earth Conductivity

System or location	Reactance per mile: Line	Reactance per mile: Earth	$\lambda \times 10^{-14}$
P P & L	0.976	0.499	1.8
Consumers	1.069	0.321	42.7
Appalachian	0.970	0.434	3.3
Alabama	0.984	0.724	0.065
Cross Keys[1]			42
Glens Falls[1]			175
Massilon[1]			36
Cross Keys[2]			33
U. S.–Canada[3]			200 to 0.1
Vicinity Chicago[4]			9
Eastern Texas			125
West Virginia			55
Penn.—Maryland			0.5
New Jersey			9
New Jersey			30
Ohio			100
Utah			30
Minn			10
Indiana			30
Maryland			8
New York			15
Penn			1
Penn			10
Wisconsin			1
Tenn			1
Ga			0.3
Ill			50
Near Ottawa			5
Oklahoma			100
Alabama			5

1. Gilkeson and Bowen, A. I. E. E. Trans., Oct. 1930, p. 1375.
2. E. P. Peck, Discussion, A. I. E. E. Trans., Oct. 1930, p. 1379.
3. E. B. King, Discussion, A. I. E. E. Trans., Oct. 1930, p. 1379. Values given are average of more than 30 tests and the statement is made that 75 per cent of the values of λ are in the range from 100 × 10⁻¹⁴ to 10 × 10⁻¹⁴.
4. This and all the values following given through the courtesy of the joint D & R Committee sponsored by the A. T. & T. and NELA.

factor dependent upon the configuration of the conductors, two values may be obtained from previously prepared tables which give directly the value of the impedance of the earth. A sufficiently accurate result for ordinary purposes, however, may be obtained from the curves of Figs. 2 and 3, based on Carson's formula with some simplification.

To apply this method it is necessary to have some idea of the values of the conductivity of the earth, since that is the final variable. Test values of earth conductivity are given in Table I. They apply to specific tests, but may be used to estimate the value of earth conductivity for other regions. The striking thing about this data is the wide variation in earth conductivity for a relatively small variation in ohms per mile impedance.

Fortunately, it is not necessary to know the value of earth conductivity with any great degree of accuracy to determine within a reasonable degree of accuracy the impedance of a transmission line with earth return. An error of 1,000 per cent, ten to one, in the value of earth conductivity will give about 30 per cent error in the earth reactance, which reduces to about 13 per cent error in the reactance of the circuit of conductor with ground return. The relative error dwindles further when the line reactance is in series with transformer and generator reactance.

In solving any particular problem it is necessary only to select the most probable values of earth conductivity for the line in question and then read off the unit values for ground resistance and reactance for the proper value of average height of line. These values in the proper relation to the test or calculated values of conductor impedance then can be inserted in equation (**1**) to give the impedance of the total circuit. The value of impedance for the various conductor groupings can, of course, be obtained by the customary method.

For values of earth conductivity at frequencies other than 60 cycles, the curves of Figs. 2 and 3 can be applied using an effective height equal to the square-root of the ratio of the actual frequency to 60 cycles. The values read from the curves also must be changed from 60 cycles to the actual frequency by direct proportion.

Circle Diagrams for Short Lines

When once constructed, circle diagrams furnish the means by which many phases of transmission-line performance can be checked quite readily. A method is given here by which the center loci are determined for a large number of short-lines where capacitance may be neglected.

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Member A. I. E. E.

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CIRCLE DIAGRAMS for transmission lines serve two general purposes: they furnish a check on long and laborious calculations, and in addition present a visual picture of the problem which mathematical solutions fail to give. Furthermore, when once constructed, such diagrams yield solutions for a large number of possible operating conditions with very little added work. For problems such as the determination of synchronous condenser capacity required for constant-voltage operation and stability, this feature is extremely valuable.

In the following discussion the visual conception and interpretation of the circle diagram is extended to include in addition to the usual factors involved, the effects of conductor size, spacing, and length. The method is particularly advantageous for use with short lines wherein capacitance is small. While this method can be used also for long lines, it loses its directness and generality in such cases, and much additional calculation becomes necessary. The treatment therefore will be restricted to the case of negligible capacitance.

Symbols used throughout the entire discussion are shown in Table I.

Table I—Symbols

P_R	=	in phase receiver power per phase in kw.
Q_R	=	quadrature receiver power per phase in kva.
E_R	=	receiver voltage to neutral in kv.
E_S	=	sending voltage to neutral in kv.
r	=	conductor resistance per mi. in ohms.
x	=	conductor reactance per mi. in ohms.
z	=	conductor impedance per mi. in ohms.
s	=	length of one conductor in mi.
f	=	frequency in cycles per sec.
D	=	conductor spacing in in.
a	=	conductor area in cir. mils.
ρ	=	resistance of conductor in ohms per mil-ft.

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The well-known general equation for the circle diagram is as follows:

$$\left[\frac{P_R}{E_R^2} + \frac{r}{z^2 s} 10^3\right]^2 + \left[\frac{Q_R}{E_R^2} + \frac{x}{z^2 s} 10^3\right]^2$$
$$= \frac{E_S^2}{E_R^2 z^2 s^2} 10^6 \qquad (1)$$

This equation represents, for a specific line, a set of concentric circles the radii of which are dependent

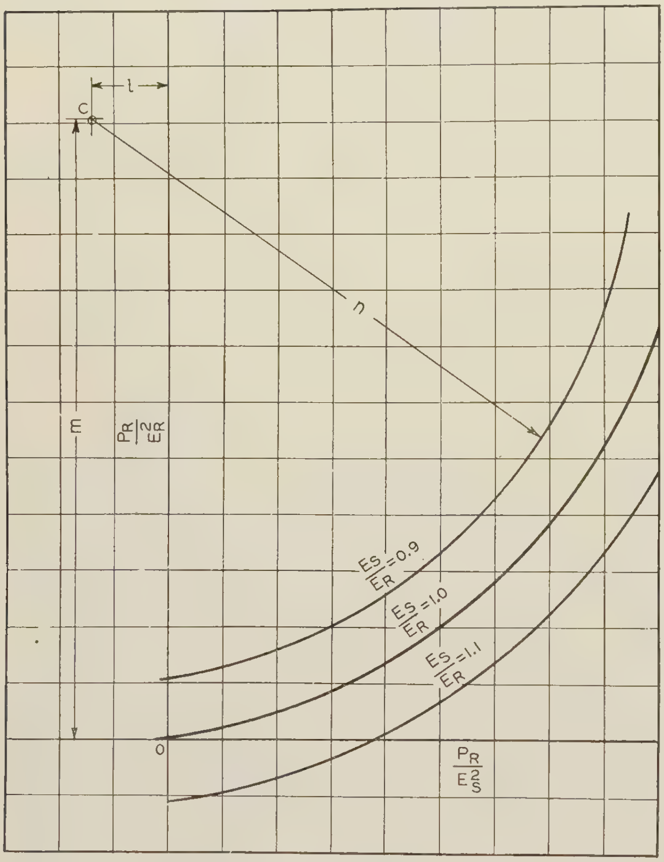

Fig. 1. General circle diagram for transmission line neglecting capacitance, where l and m are as shown in equations (2) and (3)

upon the ratio of sending to receiving voltage. The center of all the circles does not coincide with the origin but may be placed in the second quadrant at a point such as c in Fig. 1. The coordinates, l and m, may be seen from equation (1) to be:

$$l = \frac{r}{z^2 s} 10^3 \qquad (2)$$

and $$m = \frac{x}{z^2 s} 10^3 \qquad (3)$$

If the circle radius be denoted by n, then

$$n = \frac{E_S 10^3}{E_R z s} \qquad (4)$$

From equations (2), (3), and (4) may be seen that the coordinates of the center c of the family of circles and their radii are dependent upon the values of r, x, and s. These constants in turn are functions of the conductor size, spacing, and length. The usual formulas for resistance and reactance per mile may be written thus:

$$r = \frac{5280\,\rho}{a} \text{ ohms per mi.} \qquad (5)$$

$$x = 2\pi f\left(741.1 \log_{10} \frac{2\,D\,10^3}{\sqrt{a}} + 80.47\right) 10^{-6}$$

$$= 0.00466\, f \log_{10} \frac{2570\,D}{\sqrt{a}} \text{ ohms per mi.} \qquad (6)$$

The constants l, m, and n now may be written in terms of a, s, and D.

$$l = \frac{5280\,\rho\,10^3}{a\,s\left[\left(5280\,\frac{\rho}{a}\right)^2 + \left(0.00466\, f \log_{10} \frac{2750\,D}{\sqrt{a}}\right)^2\right]} \qquad (7)$$

$$m = \frac{\left(0.00466\, f \log_{10} \frac{2570\,D}{\sqrt{a}}\right) 10^3}{s\left[\left(5280\,\frac{\rho}{a}\right)^2 + \left(0.00466\, f \log_{10} \frac{2750\,D}{\sqrt{a}}\right)^2\right]} \qquad (8)$$

$$n = \frac{E_s\,10^3}{E_R\,s\sqrt{\left(5280\,\frac{\rho}{a}\right)^2 + \left(0.00466\, f \log_{10} \frac{2750\,D}{\sqrt{a}}\right)^2}} \qquad (9)$$

To determine how the locus of point c is affected by any one of the three variables a, s, or D, let two remain fixed while the third is allowed to vary. In Fig. 2 the distance s is arbitrarily taken as 10 mi. and the frequency f as 60 cycles. By taking a series of fixed values of D and plotting the locus due to variation in conductor area for each, a set of curves is found of which $F\,b$ is an example.

Similarly by taking a series of fixed conductor areas a and allowing the spacing D to vary, another set of loci is obtained as illustrated by $G\,H$. Thus for this particular line of 10-mi. length the center may be located for any spacing and conductor area if a sufficient number of curves are plotted. While the center is varying in position due to a and D, the radius n also is affected. From the geometry of the figure

$$o\,c = \sqrt{l^2 + m^2} = \frac{10^3}{z\,s} \qquad (10)$$

From the ratio of n to $o\,c$ in equations (4) and (10)

$$n = \frac{E_S}{E_R}\,o\,c \qquad (11)$$

The length of the corresponding radius for any position of c is therefore equal to the distance from c to o multiplied by the voltage ratio.

With the construction as outlined the diagram is general in regard to voltage. Once E_R is chosen the scales on the two coordinate axes become directly proportional to the quadrature and in phase receiver power. E_S is determined of course by the voltage ratio selected.

To determine how the diagram can be adapted for values of s other than that for which the diagram is drawn, (10 mi. in this case), it is necessary only to examine equations (**2**), (**3**), and (**4**). These equations show that for a given set of values of the constants r and x, or a and D, l, m, and n vary inversely as s. Therefore if a diagram for a line of 20 mi. is desired it is necessary only to divide the distances l, m, and n by two. An equivalent process which avoids the construction of a new set of curves is to divide the scales on the axes by two. In general then for any length s' the scale readings on the axes should be multiplied by $10/s'$.

As an example of the use of the chart, consider a transmission line with the following data:

Line voltage	=	110 kv.
Spacing	=	15 ft.
Conductor size	=	350,000 cir. mils
Length	=	20 mi.

Suppose that the corrective kva. at no-load is to be determined assuming a voltage ratio of 1.1. The circle drawn in Fig. 2 represents this case. The intercept on the horizontal axis is 12.5 units lagging. Then for a length of 20 mi.,

$$\frac{Q_R}{E_R^2} = 12.5 \times \frac{10}{20}$$

$$Q_R = 12.5 \times \frac{10}{20} \times \left(\frac{110}{\sqrt{3}} \right)^2$$

$$= 25{,}200 \text{ kva. per phase}$$

Other applications of the chart to practical every day problems can be shown to be equally simple.

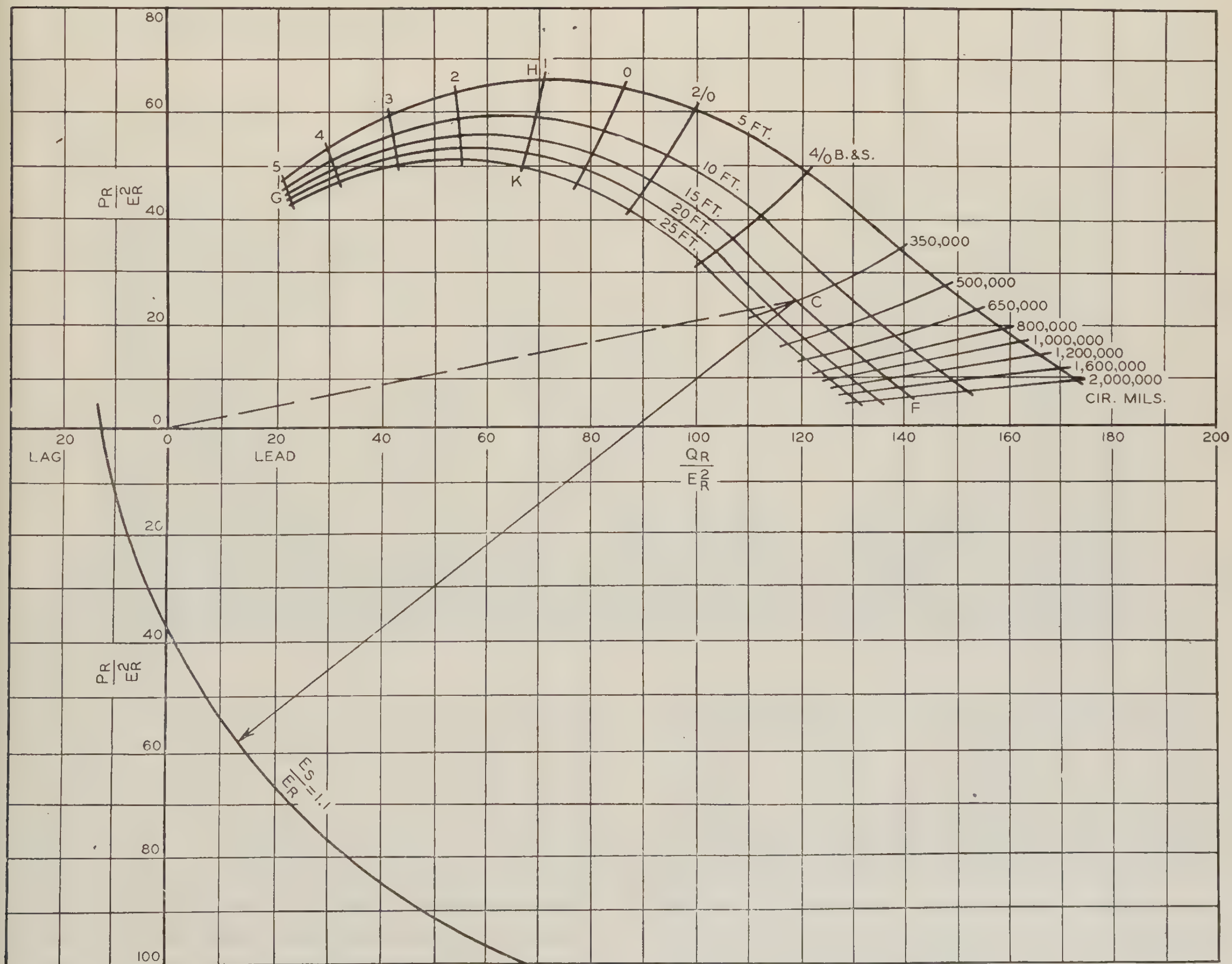

Fig. 2. Center loci for circle diagrams with typical line problem solution

Simplicity and Economy of Oil Filled Cable

Oil filled cable has been developed for successful use at the highest operating voltages. Attention now is being focused on the economies of oil filled cable systems and on means of simplifying their installation, with a resulting freedom from failure due to mechanical causes. The three articles which follow the short introduction below, discuss these factors.

In addition to improved characteristics of oil filled cable, the cable accessories have been developed so that the installation and operation of cable systems has been considerably simplified and the cost reduced. This reduction in the difficulty of installation is of considerable importance and should do much to make the use of oil filled cable at the higher voltages widespread.

DURING the past four years large installations of 132-kv. oil-filled cable and others of lower voltage rating have been placed in service. The electrical performance of all of these installations has been outstanding and each successive installation has represented an improvement in the way of simplification and economy. For ratings above 70 kv., oil filled cable is superior to the solid type in every respect; and it appears that the rating of oil filled cable can be extended to 220 kv. when required.

The term "oil filled" as applied to impregnated paper cable is understood ordinarily to indicate a cable in which the impregnating compound is of such viscosity as to be fluid at all operating temperatures. Such a cable must be constructed to permit free passage of the oil longitudinally and radially, and must be connected to a suitable oil supply. To keep the hydrostatic head of the oil from becoming excessive, oil stop joints must be inserted in the cable.

When properly constructed, such a cable system presents a number of advantages over solid cable. The free ebb and flow of the saturant removes the danger of heat expansion and consequent formation of bubbles or voids in the insulation under repeated load and temperature cycles. The deterioration of insulation is no longer an important factor to contend with, higher operating temperatures may be used, the voltage and current ratings may be increased considerably, and the thickness of insulation may be reduced. For a given size of duct more power can be carried. The dielectric loss of oil filled cable is quite low and there have been no indications of an increase in loss with time and service. Flaws and defects in the lead sheath result merely in a slow leakage of oil, which can be located and repaired at any convenient time. In solid cable the first warning of such defects is electrical service failure caused by the entrance of moisture and air.

Economics of High Voltage Cable

Careful studies have been made of the economics of the various types of cables for application in the Chicago district. The conclusions resulting from these studies are surprisingly definite, and indicate the trends in high voltage cable practise, especially as relating to the oil filled type.

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OIL FILLED CABLE for operation at 132 kv., placed in service in Chicago in 1927, was designed in 1925 to have the largest carrying capacity commercially feasible for that voltage in the state of the art as it then existed. In the ensuing years improved oil and new designs of oil supply tanks simplified the design of the terminal to the extent indicated in Fig. 1; shipping the cable full of oil and the development of methods of making joints on the cable full of oil reduced the factory cost of the cable and the cost of installation in the field; successful operating experience on lower voltage cables with devices and methods for eliminating sheath losses had removed the limitation on the economical size of the conductor. As a result

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of these developments, a second line was installed in 1930 in the same conduit as the first line, having a carrying capacity 75 per cent greater but at 20 per cent less cost. These two cables are illustrated in Fig. 3.

While the design of the line installed in 1930 was under consideration a number of other questions regarding underground transmission in the Chicago district arose, as follows:

1. What is the maximum economical size of single-conductor cable for connection between the 12-kv. bus and a 60,000-kva. transformer bank?

2. Is there any economy in the use of oil filled cable for 66-kv. service?

3. What is the maximum load per line that can be carried on 132-kv. oil-filled cable in 4-inch ducts?

4. Can 220-kv. cable be obtained if desired, and what will be the approximate cost?

It therefore was decided to review for Chicago conditions the entire subject of high voltage cable so that in addition to answering these questions, it would be possible to determine what changes in existing practise were indicated by recent developments.

Preliminary calculations on typical cables in use in Chicago indicated wide differences in the relative amounts of the various items entering into the initial cost and annual charges; and further, that the cable with the lowest total annual charges might not always be the one with the lowest first cost. Accordingly the plan was adopted of calculating curves showing, for Chicago conditions, the variations of the initial cost and annual charges for the entire range of commercial sizes so as to determine the most economical transmission voltage and type of cables for various Chicago conditions. These curves are given in Figs. 2 and 4. The investment costs include labor and supervision, conduits and manholes, joints and accessories, and cable. The annual charges include the cost of failures, maintenance, insulation loss, sheath loss, copper loss, depreciation, and interest and taxes.

The calculations were confined to cables for the transmission voltages in use except that, with some assistance from the manufacturers, 220-kv. cable was added. In determining the size, type or voltage of transmission cable, due consideration should be given to the effect on the entire system of generation, transmission and distribution of which the cable is to be a part.

As the *relative* initial and annual costs of various types were desired, it was considered more important that the unit cost figures be the same for all calculations than that they should fit any particular case. Accordingly the same physical constants, unit costs, and conditions were used throughout the calculations. Among the factors investigated which affect initial and annual costs were elimination of sheath losses on single-conductor cables, dielectric loss, maximum permissible operating temperature, load factor, and improvement in power factor of the system due to the charging current of the cables.

A study of the curves leads to the following conclusions:

1. The most economical cable for a given set of conditions should be determined by considering the total annual charges, rather than the first cost.

2. The inclusion of the terminal charges makes but slight difference in the *relative* costs of the various types and voltages of cable. This indicates that the relative costs of the various types and voltages of cable would be altered only slightly by assumptions somewhat different from those used in the calculations.

3. For every load there is one type of cable and one transmission voltage which is more economical than any other combination.

4. For a given type and voltage of cable, maximum economy generally is found with larger cables than are in ordinary use.

Fig. 1. The electrically heated terminal and oil reservoir tower of the 132-kv. cable line installed in 1927 is shown on the left, while on the right is the outdoor terminal of the 132-kv. line installed in 1930

5. Three-conductor cables are the most economical for loads up to about 50,000 kva. For the upper half of this range, three-conductor, 66-kv., oil-filled cable is the most attractive, but requires larger ducts than are now in ordinary use.

6. For loads above 50,000 kva. per line, single-conductor cable should be used.

7. The elimination of sheath losses by the use of insulating joints and bonding transformers permits the efficient use of large single-conductor cables between the 12-kv. bus and transformers for high voltage lines. The reduction in annual charges is indicated in Fig. 5.

8. For cable to operate at 66 kv., a moderate reduction in the cost of oil-filled single-conductor cable and in the cost of the joints and accessories would bring the oil filled type in competition on a cost basis with cable of the ordinary type.

9. For loads of the order of 100,000 kva. per line, oil-filled, 66-kv., single-conductor cable is preferable to the ordinary type when the overall diameter of cable is limited by the size of the ducts in existing conduits.

10. There is no economy in using 132 kv. for tie-lines between stations in Chicago until the required carrying capacity exceeds 125,000 kva. per line. In so far as carrying capacity of the cable is concerned, there is no occasion for increasing the transmission voltage above 132 kv. until the required capacity per line exceeds 250,000 kva.

11. The cost of cable for 132 kv. and higher voltages will probably limit its use to underground extensions, within large cities, of long overhead transmission lines from distant stations.

12. As the fixed charges are about three-fourths of the total annual charges, the best way to reduce annual charges is to reduce first cost.

In determining the best transmission cable for a given purpose, the decision should not be restricted by preconceived ideas of the relative importance of transmission voltage, dielectric loss, skin effect, maximum efficiency of insulation, Kelvin's law, the size or number of ducts in the conduit, or other physical laws and constants; but, by taking all such subjects into consideration, the type, size and voltage of cable and conduit details should be determined so as to secure the lowest annual charges for the given conditions.

Comparison of Insulation

At current prices and with the thicknesses of insulation now specified by the manufacturers for the various operating voltages, 66-kv., three-conductor, oil-filled

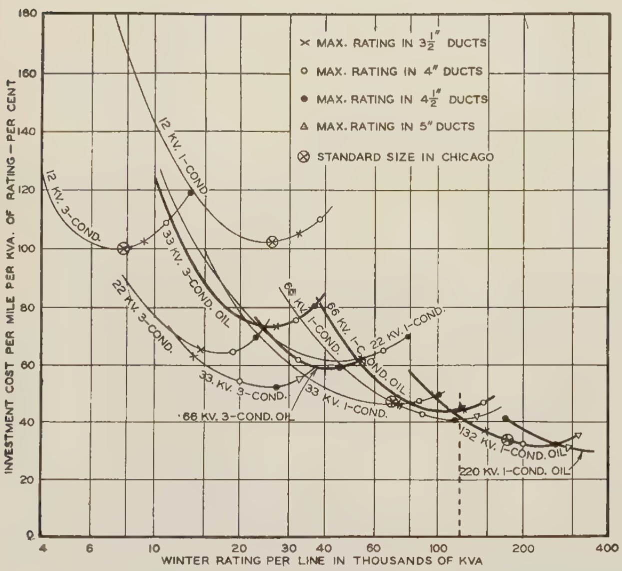

Fig. 2. Relative investment costs of underground lines, excluding terminals

One cable per duct; 6 to 10 identical cables per conduit. Minimum cost for 12-kv. three-conductor cable assumed as 100 per cent

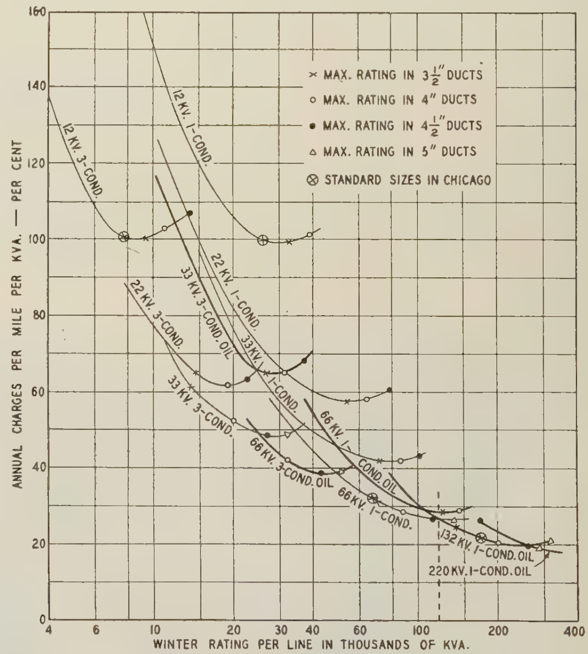

Fig. 4. Relative annual charges for underground lines, excluding terminals

Annual load factors: 12 to 33 kv., 45 per cent; 66 to 220 kv., 60 per cent. Minimum charges for 12-kv. three-conductor cable assumed as 100 per cent

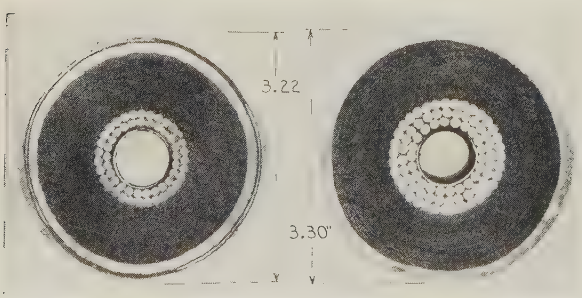

Fig. 3. The 132-kv. oil-filled cable for the 103,000-kva. line installed in 1927 (left) and for the 188,000-kva. line installed in 1930 (right)

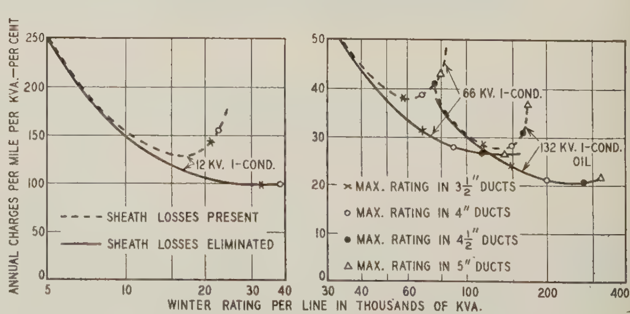

Fig. 5. Effect of sheath losses on annual charges for single-conductor cables. Load factors and vertical scale same as for Fig. 4

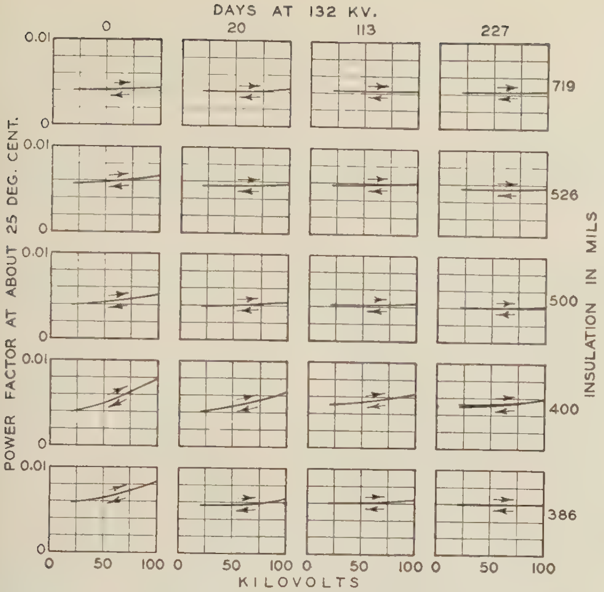

Fig. 6. Typical power-factor curves for 132-kv. oil-filled cable subjected to daily load cycles with maximum copper temperature of about 70 deg. cent.

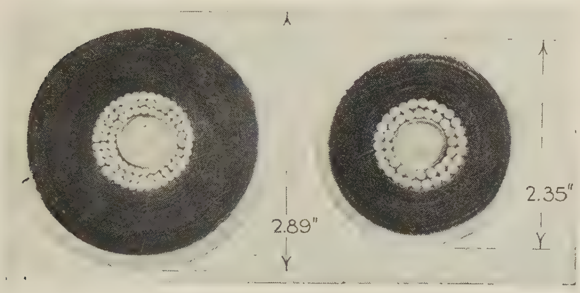

Fig. 7. 600,000-cir. mil commercial cable on the left and 475,000-cir. mil experimental cable on the right, both for same ampere capacity at 132 kv.

cable is the most economical type for loads ranging from about 25,000 to 48,000 kva. For loads ranging from about 48,000 kva. to 120,000 kva. per line, single-conductor cable with the ordinary type of insulation is the most economical. A reduction of about 10 or 15 per cent in the cost of oil filled cable and a reduction of about 30 per cent in the cost of the accessories for this type of cable would place the oil filled type in price competition with the ordinary type over this range of loads. Further reductions in the price of oil filled cable and accessories will be necessary in order to place it in competition with the ordinary type of insulation for lower voltage cable.

As indicated by Fig. 6, investigations on oil filled cable with reduced thickness of insulation, operated at 132 kv., show no adverse changes in the insulation as determined by power-factor measurements after operating for eight months with daily load cycles. Apparently the thickness of insulation now used for this voltage could be reduced safely. Present information indicates that the thickness of oil filled insulation for 132 kv. may be determined by the transient voltage

Fig. 8. Installation of equipment for eliminating sheath losses on 132-kv., 188,000-kva. cable

Left—Normal cable joints before fireproofing
Center right—Insulating joints in cable sheaths
Lower right—Bonding transformer for reducing sheath voltages

disturbances rather than by the normal stresses due to the operating voltage.

A reduction in the present thickness of the insulation of oil filled cable appears warranted by the remarkable operating record of the installations in this country, the record being that there have been over 250 mile-years of operation of the cable without any failures of the insulation. A similar record has been made by one make of 66-kv. cable with the ordinary type of insulation. This should indicate also the reasonableness of reduction of the ordinary type of insulation for 66-kv. cable.

Whether the oil filled type will displace the ordinary type at 66 kv. and lower voltages, or the ordinary type compete with the oil filled type at 132 kv., depends on the relative rates of improvement and reductions in cost of the two types of insulation with unrestricted competition.

Present indications are that the maximum temperature limit for high voltage cable may be imposed by the limitations of the lead sheath rather than by the properties of the insulation. It appears possible that the advancements in the art in the next ten or fifteen years will permit the insulation thickness for 132-kv. cable to be reduced from 719 mils to 500 mils, and the maximum temperature to be increased from 65 deg. cent. to 80 deg. cent. Fig. 7 shows the extent to which the diameter of the cable would be reduced by these changes.

When all the research investigations now in progress or contemplated by the utilities, universities and manufacturers have been brought to a successful conclusion the following results should have been attained:

1. Cables of all types and voltages will be operated at a maximum temperature of 85 to 90 deg. cent. without fear of deterioration.

2. The expensive oil reservoirs and accessories on oil filled cable will be eliminated due to:

(a) Increase in the elastic limit of the cable sheath.

(b) Reduction in the thermal coefficient of expansion of the oil.

(c) Making the insulation somewhat compressible under moderate pressures existing with the lead sheath.

3. An installation of oil filled cable will be no more complicated than a present-day installation of ordinary type of cable.

4. Cable of subnormal quality will be eliminated by tests at the factory.

5. The initial cost per kva. of 66-kv. cable completely installed will be from 30 to 40 per cent below the present cost of the ordinary type.

6. Cable failures due to all causes will not exceed one per 100 miles per year.

If all of these results should be achieved within the next fifteen years, it would be no more startling than a statement of the present day state of the art would have appeared fifteen years ago. To keep pace with the advancements being made by the manufacturers, the utilities must improve their standards of design and workmanship.

Layout of Oil Filled Cable Systems

Problems concerned with the supply of oil largely govern the layout of oil filled cable installations. Consideration must be given not only to the characteristics of the oil itself, but also to certain properties of the cable and duct structure governing the volume and pressure of oil required.

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REQUIREMENTS which must be met in order that the operation of oil filled cables be successful include the following:

1. A stable non-freezing oil of superior electrical properties. This oil should have predetermined viscosity characteristics that give assurance against void formation in the cable cross-section and excessive loss of pressure along the feed channels.

2. The wood pulp paper shall be of high quality, compactly and uniformly applied, and of predetermined density.

3. All impurities such as moisture and gas, both free and in solution, shall be removed from the cable during manufacture, and from all accessories and fittings during installation.

4. Positive pressure shall be maintained at all times inside the entire length of cable and other parts of the oil system.

5. The oil pressure should never exceed the safe working limits, determined by the mechanical strength of cable sheath and accessories.

In laying out the most effective and economical installation of oil filled cable, primary consideration must be given to the problem of oil supply including the rate of expulsion and absorption of oil by the cable, oil pressure drop along the feed channels, total expulsion or absorption of oil between the extreme limits of no-load winter temperature and full-load summer temperature, and the characteristics of available reservoirs to take care of volumetric changes in the oil caused by these fluctuations in temperature.

Typical oil demand curves of the cable, upon the sudden dropping of load, are shown in Fig. 9. Cable 1 has an inside diameter of core of 0.5 in. and a copper conductor cross-section of 600,000 cir. mils, with an over-all diameter of 2.84 in.; while cable 2 has an inside diameter of 0.5 in., a copper cross-section of 475,000 cir. mils, and an over-all diameter of 2.3 in. The measurements were made for two different oil pressures maintained in the hollow core as shown. Measurements of oil demand when the same load is applied also were taken, but the two sets of measurements coincided so closely that the latter data will not be given. The fact that these measurements coincided indicates that voids were not formed when the load was dropped.

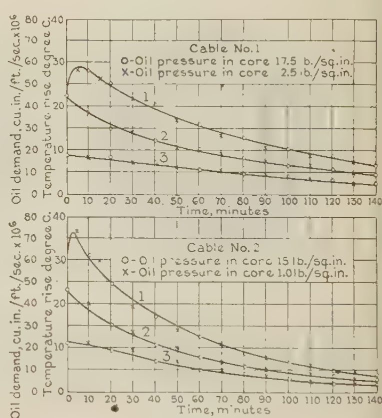

Fig. 9. Curves of (1) oil demand, (2) copper temperature rise, and (3) sheath temperature rise, after dropping load. Calculations are shown by curves, and test results by points

Also, if voids had been formed, the demand measurements with low oil pressure would be less than with the high pressure. As indicated in Fig. 9, these measurements were identical. Also, the theoretically calculated curves of Fig. 9, based on the assumption that no voids were formed, are in almost exact agreement with the test measurements.

Oil pressure drop along feed channels and piping during periods of oil flow can be calculated with acceptable accuracy only when the inner surface is smooth and cylindrical, and the rate of flow is less than turbulent. The friction factor can be calculated to allow for surfaces which are not smooth, when a spiraled supporting member is used, but it is usually necessary to confirm such calculations by test.

The total oil required is a direct function of cable length and the two extreme limits of temperature met with in service. For underground cable these limits are usually assumed as 0 deg. cent. no-load winter temperature, and 70 deg. or 75 deg. cent. full-load summer temperature. The total oil requirements can be

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calculated on this basis. Usually 40 per cent over the theoretical requirement is added to the reservoir capacity as an emergency surplus and to safeguard against possible discrepancies in calculations or wrong adjustment of reservoir content. For typical single-conductor and three-conductor cable, the total oil requirement based on the theoretical value plus 40 per cent varies from 0.5 gal. to 2.0 gal. per 100 ft. of cable.

The types of oil reservoirs which have proved most useful and desirable for oil filled cable installation are the gravity-feed reservoir and the balanced-pressure reservoir. These reservoirs are identical in design and construction with the exception that the outer rigid enclosing tank of the gravity-feed reservoir is open to the atmosphere through a breather, maintaining practically constant atmospheric pressure on the oil. On the other hand the balance-pressure reservoir has a sealed gas-tight outer tank, maintained under variable gas pressure. Both types follow the established principle of segregating and sealing-off the cable oil system against exposure to gas or other impurities. The gravity-feed reservoir must be elevated of course above its surroundings and in locations where elevation is undesirable or impractical, the balanced-pressure type may be used. These are adjustable so that units at different elevations can be made to work together.

In addition to the four factors discussed above, dealing with oil supply, there are a number of other characteristics which must be known before an oil filled cable installation can be laid out properly. One of these is the steady and transient thermal characteristics of the cable and surrounding duct structure, curves of which are given in Fig. 10 for cable 1 previously described. If full load on the cable had been dropped, the maximum rate of oil supply would have been greater than when dropping half load as in Fig. 10; however, the maximum pressure drop would have been less. This is accounted for by the difference in oil viscosity.

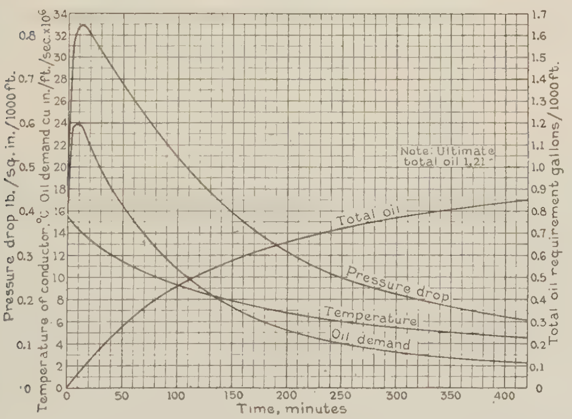


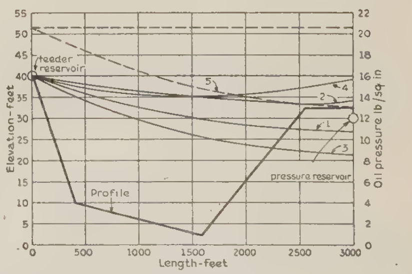
Fig. 10. Effect of dropping half load from six cables in duct bank. Based on winter conditions of 0 deg. cent. ambient earth

All of the necessary factors for cable 1 have been described and we are now in a position to lay out an actual installation. The contour of the duct run, spacing between manholes, dimensions of manholes and other practical considerations will determine the best and most economical layout. Pressure drop along the core, minimum oil pressure at high point, maximum pressure at low point and other factors will determine the location of oil stop joints and the type of oil feed for each section between stop joints. Two typical sections will be selected for discussion.

First, assume a duct contour as shown in Fig. 11, with stop joints at position 0 ft. and 3,000 ft. The sheath of cable 1 has no reinforcement and steady oil pressure at the lowest point (1,500 ft.) must not exceed 15 lb. per sq. in. Also it is desirable to avoid either a steady or transient oil pressure lower than atmospheric at any point in the oil feed system, consisting of reservoir cells, piping, stop joints and cable core. From the previous work it is known that the total rated oil capacity of the reservoir units for this length of cable is 25 gal.

Balanced-pressure reservoir feed obviously is out of the question, since the hydrostatic pressure from position 0 to 1,500 ft. is already the full allowable 15 lb. If gravity-feed units are placed at position 0 ft. and at an elevation slightly above the stop joint, the minimum pressure in the cable core when full and half-load are dropped in the winter-time is shown by curves 1 and 3. Both of these curves intersect the cable contour, and the oil system beyond these points of intersection would be at a pressure below atmospheric for several minutes. If the gravity-feed reservoirs are raised to sufficient height as shown by curve 5, this condition could be avoided; but this solution is not desirable since instead of mounting the reservoir units directly in the manhole, it would mean an expensive reservoir housing above ground level. Also, safe working pressure of 15 lb.

Fig. 11. Typical section of cable with feeder and pressure reservoirs



Feeder reservoir rated 25 gal.
Pressure reservoir rated 3 gal. oil, 15 gal. gas.
Curve 1—Pressure curve while full load is dropped in winter, feeder reservoir only
Curve 2—Same condition as Curve 1 with feeder-pressure reservoir combination
Curve 3—Pressure curve when half load is dropped in winter, feeder reservoir only
Curve 4—Same as Curve 3, with feeder-pressure reservoir combination
Curve 5—Same as Curve 3, shows height to which feeder reservoir must be raised to avoid vacuum at the far end under all conditions

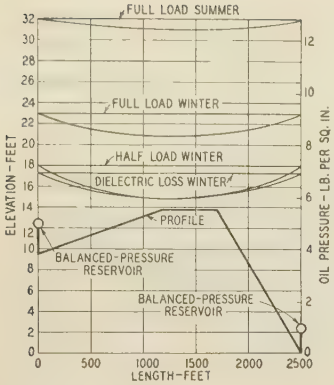


Fig. 12. Typical section of cable with balanced pressure reservoir

Oil volume—
10 gal. each reservoir
Gas volume—
41.6 gal. upper reservoir
54.0 gal. lower reservoir

would be exceeded at the lowest point of cable contour.

The real solution is to leave the gravity-feed units at stop-joint level and connect a small pressure reservoir at the low end of the section. This pressure reservoir functions only during transient periods of temperature change and during these periods assists in maintaining cable core pressure within prescribed limits. Curves 2 and 4 with pressure reservoir connected show the improvement in pressure characteristics accomplished by the addition of this small unit.

On level ground or where the profile of a given section is such that the feeder-pressure combination just described cannot be used without resorting to expensive mounting of reservoirs above ground level, the so-called balanced-pressure feed proves very convenient and economical. Fig. 12 shows a 2,500 ft. section of cable line having a contour that can be taken care of most conveniently by balanced-pressure feed. In all other respects the assumptions are the same as outlined for Fig. 11. The total rated oil capacity is found to be 20 gal. This should be divided equally, one 10-gal. balanced-pressure unit being placed at each end, the relative elevations of these reservoirs being as shown in Fig. 12.

The gas capacity of these units and their initial volumetric and pressure settings are so selected that each reservoir takes care of exactly half of the cable section. Also, the pressure at the highest point in the oil system must never drop below 1 lb. above atmospheric, and the pressure at the lowest point must never exceed 15 lb.

The pressure along the cable core under various limiting conditions is also shown. It will be noted that dropping either half-load, or merely dielectric loss in the winter and full-load pressure in the summer represent the extreme limiting conditions.

There are many factors that determine the best and most economical system of oil feed and general layout of oil filled cable installations. The best system might vary anywhere from a stop joint and reservoir in every manhole, where very rugged contour is encountered, to complete exclusion of stop joints on level ground. Generally speaking, the use of stop joints should be reduced to a minimum. Stop joints should be used merely for segregation, since the advantages gained are nullified by the additional expense and the limited amount of reservoir oil available for emergency use in case of accidental leakage.

Accessories for Oil Filled Cable

The development of more satisfactory cable joints, terminals, and reservoirs has greatly simplified the installation of oil filled cable and increased the reliability against mechanical failures.

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PARALLEL with the development of an oil filled cable for high voltage use, notable progress has been made in securing the simplicity of installation afforded by the ordinary type of cable. This factor is of considerable importance to the general use of oil filled cable for high voltages, as the difficulty of installing the earlier system handicapped its use considerably. A background of very successful practical experience now has been secured with the newer and simpler types of joints, terminals, and accessories.

The fundamental features about which this system has been built are:

1. Shipment of cable filled with oil, and without field evacuation and reimpregnation.

2. Stop joints of moderate size and cost, and a rapid and reliable technique of installation, making practicable oil feed lengths as short as desired.

3. Reliable oil feed system, including compact designs of expansion oil reservoir with oil volume indicator, and an automatic signal system designed to give to oil filled cable the same superiority over solid type in freedom from service failures due to most types of mechanical causes that it now enjoys with respect to electrical trouble.

4. For multiple-conductor cable, provision of oil channels in the filler spaces, making the system equally applicable to single-conductor and three-conductor cables.

From "Oil Filled Cable and Accessories" (**No. 31-100**) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

The cross-section of single-conductor 132-kv. cable in Fig. 13 shows the oil channel which is provided in the center of the conductor and also a number of longitudinal slots in the inner surface of the sheath which are sometimes provided to facilitate the flushing out of the last traces of air by passing degasified oil radially through the insulation. In all cases, the cable is completely dried and impregnated in the factory after leading, and shipment and installation without loss of oil is made possible by special pressure transportation reservoirs.

A cross-section of the oil supply reservoir is shown in Fig. 14. This reservoir is of the simplest type possible, with a single-unit metallic bellows enclosed in gas-tight metal casing. Severe tests have demonstrated these units to have a cyclic life far in excess of that required in service. The oil supply is contained in the bellows and pressure is maintained by gas in the outer casing. A light compression spring sufficient to overcome the inherent springiness of the bellows is used to supplement the gas pressure, and insures the oil pressure being always higher than the gas pressure, so that in case of a bellows leak the oil will leak outward into the gas instead of gas passing into the oil; and in addition, the bellows will be gradually compressed to the point where the low-volume contactor will operate.

Low-pressure and low-volume oil indicators are provided to operate mercury-tube contactors connected in the signal system. These signals are transmitted to a conveniently located control board which is equipped with a simple bridge by which the precise location of the trouble may be determined quickly.

Condenser Joints and Terminals

The large increase in dielectric strength for a given thickness of insulation resulting from the use of oil filled cable has greatly increased the difficulty of producing satisfactory joints and terminals for use on commercial lines, and has resulted in the adaptation of the condenser type of construction to this purpose.

The development of a reliable and comparatively inexpensive stop joint, moderate in size and simple to install, is a most important feature of the oil filled cable system. The availability of such a joint simplifies the problems of oil feed, and of effective sectionalizing as regards oil supply. This joint utilizes the condenser principle, and in addition to effecting reduction in space requirements over earlier stop joints, it has shown electrical strength in excess of anything previously reported. By providing substantially uniform distribution of stress longitudinally it makes possible the use of the very simple "stop tube" arrangement. This construction reduces the joint insulation in the field to little more than a simple assembly process. In addition to the barrier-type terminals which have been used for a number of years on many commercial installations up to 66 kv., and on experimental lines up to 132 kv., terminals using the condenser principle are available also for the higher voltage.

The great problem in terminal and joint design is to prevent concentration of longitudinal stress in the neighborhood of the edge of the sheath, and to secure a substantially uniform potential gradient along the surface of the cable insulation between the conductor and the sheath. This latter factor is complicated by the fact that paper insulation has a low dielectric strength longitudinally in comparison with its strength radially.

For some time it has been recognized that stress distribution by means of a series of capacitances would be a complete solution for alternating potentials, but difficulties in the details of the practical application of this method have prevented its extensive use. These difficulties now have been overcome and two designs developed fully utilizing the condenser principle. In the design first produced commercially, and used for both joints and terminals, the condensers are annular and mounted on a tube which slips over the exposed end of the conductor insulation. The construction of a terminal of this type is shown in Fig. 15. Similar principles are used successfully in the design of joints.

New Construction More Economical

A new form of construction has been perfected recently which is much lower in cost and which for joints has displaced entirely the earlier one. In this design, shown in section in Fig. 16, the condensers take the form of a nest of concentric metal cylinders *A* insulated from each other by saturated paper. At the ends of these cylinders are radial sections *B*, which are in effect conducting disks, terminating at their inner edges in short cones *C* which control the longitudinal distribution of voltage along the exposed cable insulation.

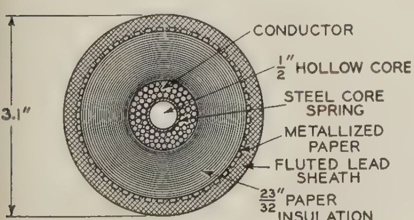

Fig. 13. Single-conductor oil filled cable for 132-kv. service

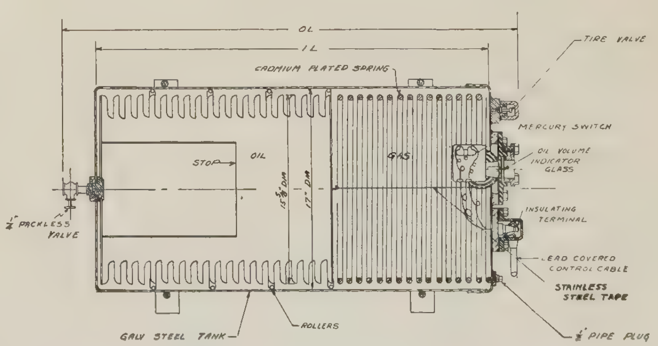

Fig. 14. Pressure type variable-volume oil reservoir

The capacity between successive cylinders and their corresponding potential is controlled by varying the insulation thickness between them, or by the use of several cylinders connected in parallel as shown at *D*. The angle of the conical portion is calculated to give substantially uniform potential gradient between adjacent cones, and to prevent concentration of stress at the inner edges. This angle is smallest near the end of the sheath and increases toward the center of the joint.

In practise, the complete group of condensers is built up as a separate, self-contained unit. A long strip of paper is wound on a tube of rigid insulating material referred to as the "condenser tube" thin sheets of metal being inserted at appropriate intervals to form the cylinders *A*. The inner cylinder is connected to the cable conductor through a metal ring inset in the tube, and spring contactors mounted on the splice connector. The cones *C* and disks *B* are formed by winding on with the paper, narrow metal tapes fed from spools which move longitudinally to the axis of the joint to produce the desired taper. When the winding is finished the complete unit is incased in a thin sheet of corrugated copper, vacuum dried, and then saturated with insulating oil and the casing sealed, thus forming a compact unit which can be easily handled and installed by simply slipping it over the joined ends of the cables.

The longitudinal stress in the oil films between the condenser tube and stop tube, and between the stop tube and the conductor insulation, is controlled by the condenser construction and by the angle of taper used on the conical metal socket into which the stop tube is mounted at the outer end. With very thin high-strength cable insulation, however, the radial stress on the film within the stop tube may be excessive. To prevent this, it is ordinarily found desirable to build up the conductor insulation with a tube of impregnated paper slipped loosely over the end of the cable and tightened up by twisting. In this way the radial stress in the oil films may be kept well below that which will produce ionization. This same construction is used also with excellent results in non-stop joints and in terminals of both the barrier type and the condenser type.

Increased Longitudinal Strength

By this construction it has been possible to obtain substantially uniform longitudinal distribution of stresses. The limiting feature of design has become the actual longitudinal strength of thin oil films and of the impregnated paper in a direction parallel to its laminations. In earlier designs of joints and terminals it had not been possible to develop this strength, and consequently there has been very little previous work to determine specific values of electrical strength in this direction. For this reason a large number of tests has been made on laboratory samples simulating the con-

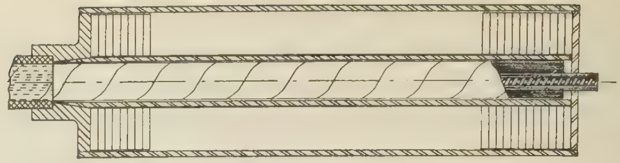

Fig. 15. Elements of test terminal with disk condensers

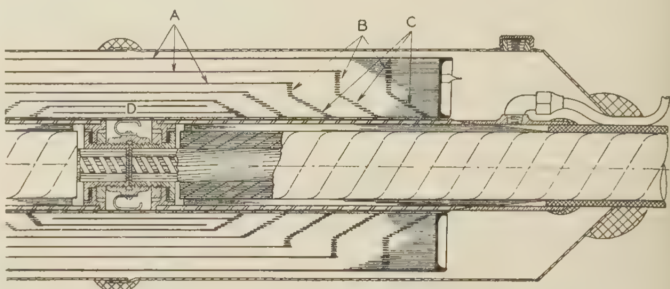

Fig. 16. Condenser joint with cylindrical condensers

ditions found in the condenser unit and using oil films approximately 1 mil thick. When tested at 20 lb. per sq. in. gage pressure, a longitudinal strength of 40 to 60 kv. per in. was indicated. No reduction of strength with time of application of voltage was observed. Breakdown voltage was roughly proportional to the square root of the distance between electrodes, and to the eighth root of the absolute pressure. On completely assembled joints having a total of 14-in. longitudinal creepage distance, tests have been made up to 300 kv. for approximately eight hours without failure, and proportional results have been obtained on smaller joints.

In earlier designs of joints and terminals for very high operating voltage, the difficulty with concentration of stresses increased with increased voltage, so that a small increase in voltage necessitates an entirely disproportionate increase in dimensions. As a result, a rather definite limit was established beyond which further increase in voltage was impracticable. With the uniform distribution provided by the condenser construction, increase in voltage merely requires a proportional increase in the number of condenser steps and the design of joints and terminals for any desired voltage for which cables later may be built becomes a simple matter of adjustment of dimensions.

These developments have made possible a unified cable system combining the inherent advantages of the oil filled principle with certain features which contribute greatly to simplicity and reliability. These features include ease of installation, efficient sectionalizing, and provision for prompt detection of oil leaks or abnormal pressures. As a result, freedom from electrical failure, which is characteristic of oil filled cables, may be expected to be matched by freedom from service failures due to most of those external and mechanical causes which result in failures on the present solid systems.

The Transfer of Skill to Russia

A native of Russia, speaking the language and familiar with the customs and habits of its people, the author has come to the conclusion that Russia's principal problem in her industrial development is one of management. On the basis of 25 years of professional engineering experience in the U.S.A. and a recent 18-month professional engagement in Russia, this conclusion has been reached.

By
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TO ACCOMPLISH the gigantic and ambitious program of changing within perhaps a few years the most backward country into a modern industrial land of Soviets is the aim and determination of the mass of the Russian population. The leaders of that country are charged with this tremendous responsibility and millions of workers, communists, and ordinary citizens are watching sharply every step toward the fulfilment of their Five Year Plan.

Last February the Conference of the Industrial Executives passed the resolution to accomplish this task in four years instead of five, and in the more essential industries in even three years. The speed of this progress was made the essence of the program. Stalin pointed out that in the past, Russia was defeated constantly because of its alluring richness and defenseless backwardness. Another reason for this acceleration is the dire need of consumers' goods such as clothing, shelter, and food, the shortage of which may be endured by the hardy and fatalistically inclined population for just so long, but not indefinitely. The third reason for this unheard of speed of development may be found, although it never has been admitted, in the psychology of the population. Four hundred years of despotic monarchy, browbeating officials, and economic slavery to landlords resulting in a low standard of living, were blended gradually with the passive slavic, almost oriental easy going slow tempo of the primitive agricultural life, so that in order to take the population out of this static inertia and accelerate it nothing but this kind of complete change to the great speed of preplanned activity would do.

The slogan "catch-up with, and overtake the leading industrial countries" coupled with the ambition formulated on banners and posters throughout Russia calling the people to become the "leaders of the world" gives them the courage to live in the anticipation of better days and easier life after the Five Year Plan is completed.

Meanwhile, they need machinery and the skill to use it. To build plants and factories and to open up the mines is relatively easy. To be sure, one needs cash or credit for the purchase of equipment, and as this must be bought in Europe or America, it involves export for exchange of Russian goods for foreign equipment. Since the world-wide industrial and financial crisis the prices went down, but the terms of orders previously placed remained. Hence, Soviets have to export more than they had planned in order to pay for the equipment under contract. This is obvious, and the people must put up with shortages of every kind at home.

Yet what is not so obvious is that after factories are built and machinery installed, goods must be produced. This constitutes a real problem and a particularly grave one under the circumstances.

Competent Management Needed

Nowhere in the world is the old adage that, "large plants and perfect equipment is of no avail without proper management" as glaringly true as in Russia today. Since production rate depends primarily upon organization for execution of plans, it requires the executive direction and managerial skill and the technological knowledge and habits of modern industry.

In U.S.S.R. is found a remarkable political organization, but industry and politics are not congruent. To organize a revolution demands different qualifications from those necessary to organize production. The leaders of Russian development begin to sense this fact. Stalin bluntly pointed out on various occasions that his comrades failed to learn the technique of production management. He made this point very clear when the last year's records were announced, showing a 25 per cent increase of production, an unprecedented rate of growth, instead of the expected 31 per cent. This year's plan anticipates a further 41 per cent increase in production. Newspapers are full of appeals and warnings. Recently correspondents from Moscow heralded Stalin's new economic policy with the center of gravity shifted from construction and machinery to the operation and human element. This was inevitable. In our personal experience, a well equipped, fully manned machine tool plant raised its output more than 400 per cent in a few months by introducing the simplest methods of modern technique of management.

An address delivered June 18, 1931, before the New York Chapter of the Society of Industrial Engineers. *Not published in pamphlet form.*

What does it mean and what is the cause of it?

On the surface, it means that young Russian industry could save 75 per cent of the investment in new plants and factories if the other 25 per cent were managed properly, or that it could produce at least four times more on investments. But is this merely a theoretical consideration or is it a practical, immediate possibility?

In the past, the extent of Russian industry was insignificant when compared either with the natural resources of the country or with its present extension. This meant a relatively small number of engineers and executives. Many of that number are not available at present; some unwilling or psychologically unfit to render service under the vastly different social economic set-up. At the same time, hundreds of large industrial establishments being annually added and put into operation demand large cadres of executives and engineers. In parallel with the construction of new plants, Russia's plan provides for the establishment of new technical schools with short intensive training of a highly specialized engineering staff.

Most if not all large plants have technical schools under their aegis, seeing to it that young men and women are receiving necessary instruction in close contact with industry and meeting its needs. These students are workers themselves, with years of practical experience, working eagerly and tirelessly in various fields, gradually forming a new type of practical specialist so much needed in modern mass production based on standardized methods. Furthermore, foreign engineering contractors selling and installing equipment usually furnish instructors to demonstrate the use of their equipment and the process of manufacture.

But here the difficulty begins. Buying a machine on a guarantee basis so that it is capable of turning out such-and-such an hourly production, does not mean and cannot mean that the plant as a whole, even if completely and properly equipped with a full complement of productive and auxiliary equipment, actually will turn out the specified volume of finished product. The simple truth that such an efficient performance demands as an unconditional prerequisite a well-devised, systematic management and a competent executive control, is as yet not fully recognized by a sufficient number of the political and industrial leaders of that country.

Shop Experience Lacking

The lack of actual shop experience in administration and management and the enthusiastic belief in guaranteed "machine capacity" leads them to expect that the personal efficiency of workers alone can accomplish the desired results. Too often when there is a shortage of output or falling behind of production programs, the salvation is sought in the so-called "shock brigades," and not in the strengthening of the mode of management. These "shock brigades" are composed of volunteer workers pledging themselves to increase the production by all means within their power. They do, at least temporarily, a measure of good. By their enthusiasm and example they often improve the shop morale, reduce tardiness and absenteeism, make steady work during the shift socially respectable, provide stimuli for reduced spoilage, lower expense, and promote general economy; but they cannot and they do not bring order out of chaos. As a matter of fact, an efficient "shock brigade" frequently so outstrips the rest of the workers that the management without the aid of proper dispatching, scheduling, and control of the flow of production, finds itself facing an utterly unbalanced inventory of finished and semi-finished parts, with operating capital tied up and with the actual output but slightly improved.

It is difficult for those in America to realize fully the managerial handicaps so characteristic of the giant infant—Russian Industry. We hardly ever stop to consider what a predominant proportion of our industrial activities is carried by the established standard of procedure; how much specialized knowledge is available for the asking from a supply firm, sales engineer, or a foreman or superintendent with a vast experience elsewhere, and even from a competitive firm. We are in the habit of dividing the operating problems into two great classes: *routine* and *exceptions.* Under the first class fall all functions that are well standardized either by tradition or by analysis, all of these being handled by clerks and various supervisors. Under the second class we place all the unusual and emergency occurrences which fall under the jurisdiction of specialists or executives. They are relieved of all routine work, but as soon as production gets out of balance, supply is disrupted, personnel demoralized, distribution crippled, expenses and prices take a swing, or a new line of production is contemplated, these executives step in, mind-free from all the normal operating details which are left to the standardized functions of the routine men.

There is no such clear division of responsibilities in Russia. We read time and again in local papers, and ourselves have observed that in the plants managers having no information to rely upon and to be guided by, instead of taking their time and studying such methods, waste their time by walking miles and miles daily through the vast shops hoping mostly in vain, to find on these sightseeing tours some important items requiring their executive attention.

This absence, or near-absence, of an established routine of standardized procedure is of course a normal thing in a young industry grown almost overnight and having no past on which to base useful traditions. Nevertheless, the harm and waste resulting from this lack of functionalized division of responsibilities is very great; but the chances are that it soon will be in disrepute.

There is no doubt that Russians can learn things quickly. A group of Japanese undertook to teach them how to organize locomotive repair work with the

result that what used to take weeks now is being done in a few days. We Americans showed them how to quadruple their machine-shop output without adding equipment or changing the design of the product, merely by getting the flow of work under control with the aid of Gantt charts and other purely managerial means. They begin to realize the importance of this transfer of skill. For instance, an American textile engineer was engaged to prepare a full set of standard practise instructions for the headquarters responsible for the organization of the textile industry.

All of us are familiar with that naive emotion which may be termed "the lure of the machine," that admiration of its almost intelligent working, that awe of its superhuman power, and that great expectation of the beneficial results to be derived from it. We learn, however, that the machines are a liability, not an asset, until brains are employed to organize their utilization. A million dollar plant producing $600,000 work of goods, if operated at half its capacity, causes $130,000 annual loss. Assume now that there is the demand for double the output. It can be secured by two means: double the plant at an investment of another $1,000,000 and increase the payroll by another $100,000, or else utilize the existing plant with double efficiency by means of modern managerial technique. Are such services worth, say, half of the $130,000 a year previously wasted because of the absence of such specialized skill, or is it more economical to incur an added obligation of $300,000 for the physical extension of the plant capacity under the old management?

Naturally, the European manufacturers seeking a market for their machinery in the rapidly growing U.S.S.R. are advocating the second method of new investments, suggesting at the same time that their unemployed technicians may go to Russia and transfer their skill, no longer needed at home, to demonstrate the operation of the important equipment for a compensation commensurate with the depressed hope of finding a job at home.

The Problem

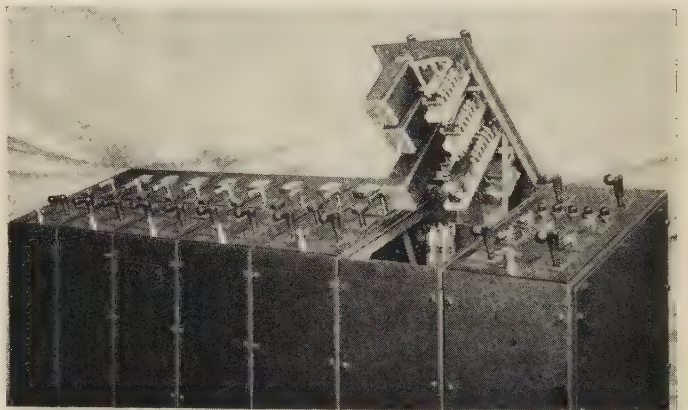
And then what? Mines are mechanized, new plants erected and equipped, factories rejuvenated by the new machinery, *but* the degree of their utilization, due to old fashioned organization, lack of administrative experience, and absence of management technique and executive training remain nearly as low, if not lower, than before the enlargement due to the dilution of the executive and managerial forces by the as yet inexperienced newcomers placed in charge of new plants and extensions.

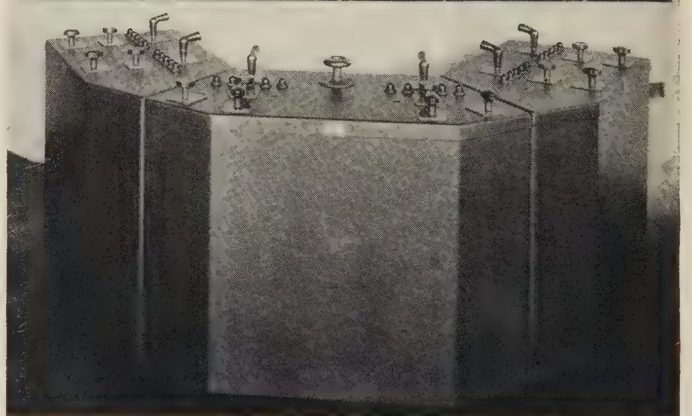
Such seems to be the main problem confronting the fulfilment of the Russian "Five Year in Four Plan" today and its future destiny. There is an alternative: either to burden the country with an additional mass of the means of production for generations inadequately utilized, or to transfer the managerial skill, to accelerate the period of learning and, in the words of one of the vice presidents of the Supreme Economic Council of U.S.S.R., to get rid of that "ugly, oriental expectation of miracles from new machinery."

In the light of our American experience, especially since the days of Gantt, and in view of the European seeking of advice of American management engineers, it appears as a foregone conclusion that the U.S.S.R. must and will follow both roads. First she must build up the industry with essential equipment; but next, if she does not want to ruin the equipment by poor attendance, and if she wants to obtain full results from the investment made, she should definitely commit herself to the transfer of managerial skill on a par with the importation of machinery.

Upon this decision apparently rests the answer as to how well Russia will fulfil her Five Year production program.

Compact Industrial Control





General Electric Photo

SOME of the trends in industrial electrical control as exemplified by recent steel mill installations are indicated in the accompanying illustrations. A seven-panel control desk built for use in connection with a 65-panel switchboard may be seen in the upper illustration. This board although only 98 in. long, and 30 in. high in front, accommodates full control for nine large d-c. motors and five d-c. generators, motor controls including reverse, and fine and coarse speed adjustments.

Unity Power Factor For Neon Tube Signs

Application of parallel capacitance will not correct the power factor of the usual commercial neon tube installation to a value greater than 90 per cent. A constant-current circuit for use with these signs is described in this article, which not only operates at unity power factor but possesses other advantages.

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ATTEMPTS to correct the power factor of neon tube electric signs by the use of parallel capacitance have not been altogether successful. Although sufficient capacitance can be added to shift the apparent phase position of the current wave to the phase position of the voltage wave, this will not provide for unity power factor because of the non-sinusoidal nature of the current wave. While in most cases power factor correction for this type of equipment cannot be justified from the cost standpoint, nevertheless the circuit described here does provide power supply at unity power factor and without presenting any additional difficulties either of an economic or engineering nature.

Operating Characteristics of Present Equipment

Since the resistance of a gaseous conductor tube is practically in inverse ratio to the current flowing through it, in order to limit the current its power supply must be received through a high series impedance. This impedance must of necessity be essentially reactance, as a direct power loss would result if resistance were used for this purpose. In the past this higher reactance has been obtained most economically by using a supply transformer with abnormally high leakage reactance. (See Fig. 1.) Low power factor results from the use of transformers of this character, being usually of the order of from 30 to 40 per cent.

Written especially for Electrical Engineering. *Not published in pamphlet form.*

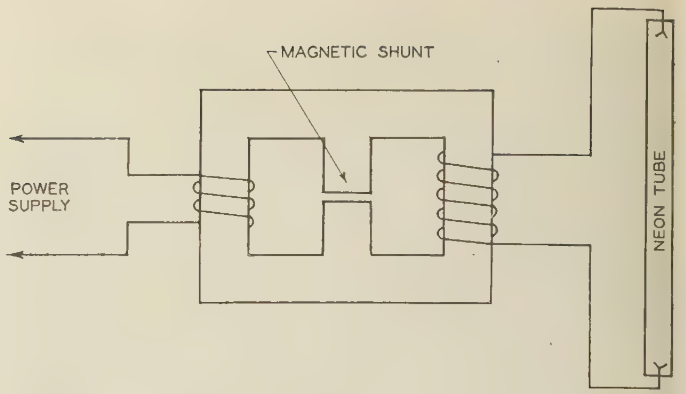

Fig. 1. Schematic diagram of ordinary neon tube installation with high-leakage-reactance transformer

When these high-leakage transformers are connected to lines having sinusoidal voltage waves, a current wave of non-sinusoidal form will flow as indicated in Fig. 2. The current wave in this particular case lags the voltage wave by about 72 degrees (31-per cent power factor) and was found to contain both third and fifth harmonics of appreciable magnitude. If capacity reactance be paralleled with the transformer primary in an effort to improve the power factor, the optimum power factor will be obtained when the fundamental component of the current wave is in phase with the impressed sinusoidal voltage wave. Under these conditions the harmonic components of the current wave will remain unaltered since with a sinusoidal impressed voltage, capacitance can draw only current possessing a sinusoidal wave. For this reason the best power factor which can be obtained in this manner is only from 80 to 90 per cent.

Constant-Current Circuit

A number of constant-current circuits have been developed from time to time in the past, especially for application to arc-light service. One such circuit as described by Steinmetz in his "Theory and Calculation of Electric Circuits," has been adapted for neon tube operation. This is shown schematically in Fig. 3.

With this arrangement, current supplied to the transformer primary by the constant-current circuit will at all times bear a constant numerical relation to the impressed voltage regardless of the transformer impedance. Thus the high impedance of the transformer on no-load during the start of each half-cycle and before the breakdown of the neon tube load on the secondary will give secondary voltages of sufficient magnitude to induce ionization in the neon tube, if the transformer turn ratio be appropriate. As soon as secondary breakdown has been effected, the impedance of the transformer drops lowering the transformer primary voltage required to maintain the current to the point where the primary voltage times the turn ratio equals the secondary voltage required to sustain current flow in the neon tube.

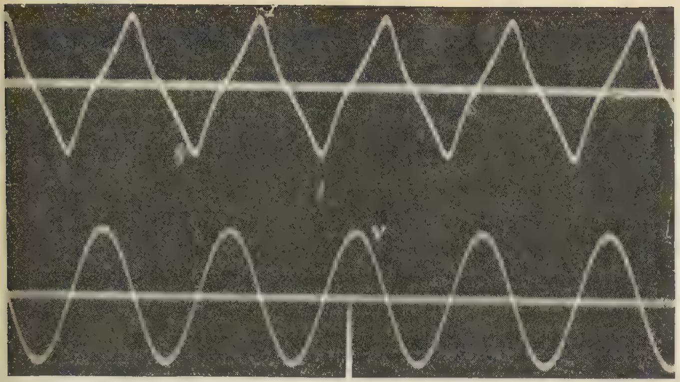

Fig. 2. Current (I) and voltage (V) waves for typical neon tube installation such as shown in Fig. 1

The oscillogram shown in Fig. 4 shows the current wave as taken from the line by this circuit with a sinusoidal impressed voltage. The current wave also is of sinusoidal form and is in phase with the voltage.

Advantages of Constant-Current Apparatus

A series of comparative tests were made to show the relative advantages of the constant-current circuit as compared to those of the high-leakage transformers now being used. In these tests the light output of the neon tube was determined by means of a photoelectric cell placed adjacent to the tube. A microammeter and a 90-volt battery were connected in series with the cell. The microammeter indications thus gave a measure of the light output of the tube. Since only comparative results were desired, the readings were used directly without conversion into equivalent light output.

Results of this series of tests are given in the accompanying tabulation. It may be noted that the proposed constant-current circuit gives a ratio of light output to watts input midway between those obtained from the two commercial transformers tested. Also the capacity reactance required to bring about the best power factor is lower for the constant-current circuit than for the standard commercial transformer circuits. Unity power factor was attained readily with the constant-current circuit while for the corrected standard commercial transformers the best obtainable was not over 90 per cent.

Cost Comparisons

Although no accurate data are available showing the relative costs between inductive and capacity reactances for service demands such as those involved in this application, a careful estimate shows that the reactances used in the proposed circuit should cost somewhat less than the parallel capacity reactance required to furnish the maximum correction for a commercial type, high-leakage-reactance transformer.

The constant-current circuit requires less current in its transformer primary winding than does the corrected

Comparison Between Constant-Current Circuit and High-Leakage-Reactance Transformers

Item	Constant-Current Circuit	Commercial Transformer No. 1	Commercial Transformer No. 2
Minimum primary current, amperes (r. m. s.)	0.265	0.350	0.354
Power factor, uncorrected	1.000	0.319	0.312
Best power factor obtainable	1.000	0.908	0.808
Capacity reactance required, μf	12.45	21.40	19.20
Power in watts	30.40	36.23	32.45
Secondary current, milliamperes	15.00	15.00	16.10
Secondary milliamperes per watt input	0.493	0.413	0.496
*Photoelectric current, microamperes	9.90	9.90	11.10
Photoelectric current/watts input	0.326	0.272	0.342
Same as above, with maximum power factor correction	0.326	0.286	0.359
Photoelectric current/amperes line current	37.30	38.30	31.30
Same as above, with maximum power factor correction	37.30	10.30	12.50

*These readings not translated into equivalent light output since comparative results only were desired.

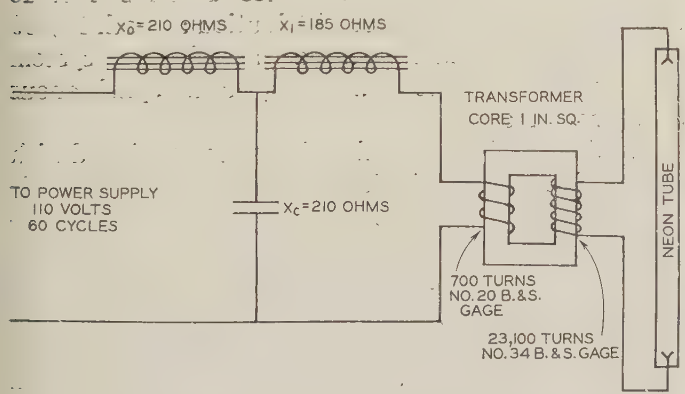

Fig. 3. Constant-current circuit for supplying neon tubing at unity power factor; constants used in the experimental set-up are shown

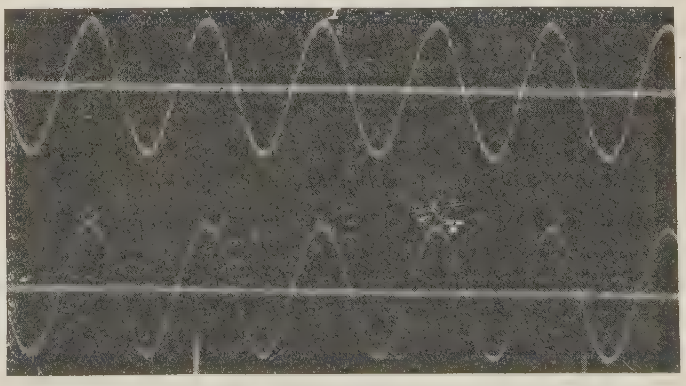

Fig. 4. Current (I) and voltage (V) waves for constant-current circuit of Fig. 3. Note "in-phase" sine-wave current

or uncorrected magnetic-shunt type of transformer now in use. Thus a smaller size of wire may be used in the primary circuit of the transformer used in the constant-current circuit with a corresponding additional saving in cost.

In addition to the advantages already mentioned, it is necessary to mount only the transformer of the constant-current circuit on the neon tube sign itself; the reactances may be mounted inside of the building. The constant-current transformer has the further advantage of requiring less space than the magnetic-shunt type.

As stated at the outset, the general use of corrective circuits or other means of raising the power factor of gaseous conductor lamps cannot be justified in most cases from the standpoint of economy. However, the solution presented here corrects some of the defects or errors of the earlier solutions without presenting additional difficulties either of an economic or engineering nature.

Operating Experiences with Automatic and Supervisory Control

Records have been kept by three different investigators on various types of automatic equipment for station control. These results are summarized in the following articles.

PROGRESS in the development of automatic equipment and in its application to the control of electrical energy has followed very closely the phenomenal growth of the industry itself during the last decade. Automatic equipment was applied first to the control of small outlying transformer stations. As the success of these installations was established and new control schemes and devices were developed, the application has been extended to include practically all types of stations. The chief reasons for this wide popularity are that the first cost of the station is increased but little while reliability and flexibility are as good if not better than with an attended station, and operating costs are materially less.

In the group of three articles following, the experiences of several years' operation on different types of equipment for automatic and supervisory control of railway substations, a-c. distribution substations, and generating stations are presented. The authors of each article have given a summary of records on their equipment, kept over a period of years and presenting principally the operating troubles most frequently experienced.

Automatic Control of Substations

By
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AUTOMATIC and semi-automatic stations of various types have been in operation during the past ten years on the system of the Columbia Gas and Electric Corporation. These stations include transformer substations for distribution at both 13,200 and 4,325 volts, street railway and Edison system synchronous converter stations, and synchronous condenser installations.

The distribution substations have been equipped with automatic reclosing oil circuit breakers and automatic induction voltage regulators on the feeders, with load-response equipment included in the transformer bank control. The street railway converter stations and two Edison system motor-generator sets are completely automatic in operation. The control of the converters is designed to function on voltage variation

From "Operating Experiences with Automatic Stations, Part I—Columbia Engineering and Management Corporation" (**No. 31-94**) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

and load demand, and includes many other features incorporated in the latest designs for this class of equipment; the circuit breakers on the d-c. feeders open on rate of rise of current and reclose when the circuit is clear. The synchronous condensers and all Edison system synchronous converters are equipped with semiautomatic control. This scheme includes complete starting operation when initiated by the operator, voltage regulation, load-limiting devices and other protective functions. The operation of any protective device in an automatic station transmits a signal to the office of the system load dispatcher.

It is realized that the class of service secured from any type of automatic station is dependent directly upon the excellence of inspection and maintenance. In the Cincinnati district there are five automatic-station operators, carefully selected and trained; their duties include the inspection and maintenance of fourteen stations. An effort is made to have an operator visit the more important stations once a day and the smaller stations two to three times a week for a regular inspection. This inspection consists of making the necessary meter and operation counter readings, adjusting graphic meters and changing the charts, adjusting battery-charging equipment, checking temperatures and general operating condition of all apparatus, checking indicating lamps, fuses, and grounds on control circuits, and in the case of rotating equipment observing the starting and stopping sequence. Once each week the rotating apparatus and all of its control equipment is cleaned and if necessary repaired, and a complete check is made of the proper functioning of all devices. Once every two weeks the equipment on each reclosing feeder is given the same general overhauling. Once each week all the control batteries are given a slight change and their condition checked. Finally, twice a year all the apparatus in the station is given a complete overhauling by the regular maintenance crew under the supervision of the automatic substation operators.

Upon looking back over the operating records of the distribution stations it is noted that at least 90 per cent of the faults on a circuit are temporary in nature and that the breakers remain closed after the first or second operation. These circuits having automatic reclosing circuit breakers are equipped with instantaneous overcurrent relays set to operate at a predetermined value of current which is slightly below the safe rupturing capacity of the circuit breaker, or the thermal capacity of the regulators. The operation of these relays prevents the reclosing of the circuit breaker until the fault has been cleared and the relays reset. To date there has been only one operation of these relays, which was caused by a cable failure near the station. By the use of such relays it is considered safe to install equipment having lower capacity, or to make the time between circuit-breaker reclosings less than otherwise advisable.

On the system of the Dayton Power and Light Company several automatic distribution stations are in operation. These stations are of the outdoor type having reclosing circuit breakers equipped with a-c. motor-operated closing mechanisms and 24-volt d-c. trip coils. So much trouble has been experienced with this type of control that except for special cases no similar equipment is being considered for future installation. The auxiliary switches are a source of perpetual annoyance and the centrifugal closing mechanism has a tendency to lose its adjustment and cause the breaker to "pump," or else fail to close altogether. It has been decided that future installations of this nature will include solenoid-operated breakers with a control battery, or some similar source of supply. Since the cost of the solenoid mechanism is less than the motor mechanism, this compensates to some extent for the additional cost of the control battery.

One of these stations was supplied through a tap connection on the double-circuit 33,000-volt loop around the city. Approximately two years ago this station was rehabilitated and 33,000-volt sectionalizing equipment was installed. At this time the control scheme was changed from automatic to supervisory, and is operated from the dispatcher's office approximately four miles distant from the station. The only source of trouble experienced on the installation to date has been due to interference by the telephone company from which the interconnecting wires are leased. Another point of some interest in this station as well as in automatic stations in general is the use of diverter-pole-type motor-generator sets for control battery charging. In case of complete outage of the station it was found that this set could be started automatically and reconnected to the battery without super-

Fig. 1. Typical regulator structure showing installation of Lux fire extinguisher

vision. It is the practise at all times to float the motor-generator set across the battery.

In addition to the above stations this company has been operating four automatic street railway converter substations for approximately ten years. A great deal of trouble was experienced with these installations due principally to the use of the old plunger and bellows types of relays. These were not as accurate or reliable as the present induction relays and motor-operated timers. Practically all the original relays have been replaced by relays of later design and very little trouble from this source is anticipated in the future.

Listed in the order of frequency of occurrence, the chief items of trouble experienced in these automatic stations are: (1) improper adjustment of graphic meter pens and clocks, (2) loss of adjustment of circuit breaker auxiliary switches and closing mechanisms; (3) grounds on control circuits; and (4) relay troubles due to obsolescence and loss of adjustment.

It is to be concluded from the results of these experiences that when properly operated, the automatic station is equal to and in some respects superior to attended stations in reliability and flexibility. On the whole it is found that automatic equipment will perform the necessary functions more accurately and faster than could be expected of any operator. This results in an improvement in continuity of service by decreasing outage time, thus increasing revenues as well as good-will. At the same time, the duties of the system load dispatcher are lightened, permitting him to give his attention to the more important matters in times of major system disturbances, with a resultant increase in total system efficiency.

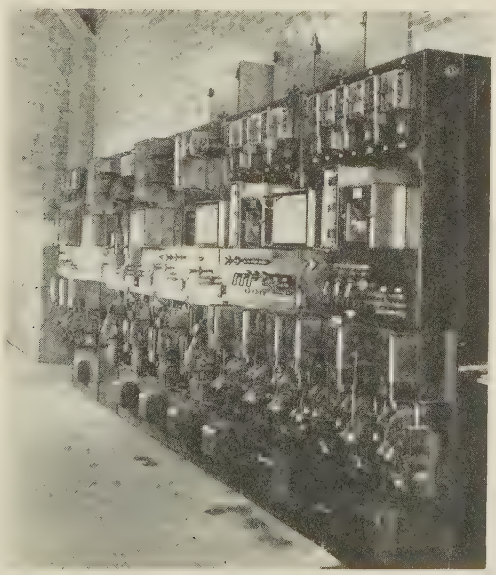

Fig. 2. 4,325-volt metal-clad switchgear showing mounting of relay and control equipment

Automatic and Supervisory Control of Substations

By
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THE POLICY of the Toronto Hydro-Electric System is to locate moderate-sized distribution stations near the economical load centers and equip them for automatic or supervisory control. These automatic and supervisory equipments include all the more prominent types as well as equipment developed by the Toronto system for its own use. In addition there is at present a Gamewell signaling system which is used for giving signals to the load dispatchers when switches open automatically in small unattended transformer stations where supervisory control has not been provided.

The automatic control for synchronous converter stations is arranged to start the converter on load demand determined by a contact-making voltmeter, and to shut down the unit when the load is reduced to an economical point. Two schemes are used on the Toronto system for accomplishing this result; the General Electric scheme in which a drum controller initiates the various operations in proper sequence, and the Westinghouse scheme in which these steps take place through the guidance and control of relays and interlocks functioning according to a predetermined plan in a step-by-step fashion. Both types of equipment have given satisfactory operation for over nine years, although a few troubles have been experienced. The principal difficulties with General Electric equipment are as follows:

1. When first installed the timing relays gave trouble and had to be replaced.

2. The field relay did not function properly, and required a new coil.

3. Some trouble has been experienced with the brake-bands on the brush-lifting mechanism, making replacement necessary.

4. An open circuit in the exciter generator used for correcting polarity occasioned considerable operating difficulty before it was known that this was the trouble.

With the Westinghouse scheme most of the troubles occurred during the first year, and since their elimination the equipment has given very satisfactory operation. The troubles were as follows:

1. The latching relay on the oil switch required modification.

2. Trouble was experienced with the contacts of the auxiliary switches controlling the main contactors, making it necessary to modify these devices.

From "Operating Experiences with Automatic Stations, Part II—Toronto Hydro-Electric System" (No. 31-94) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

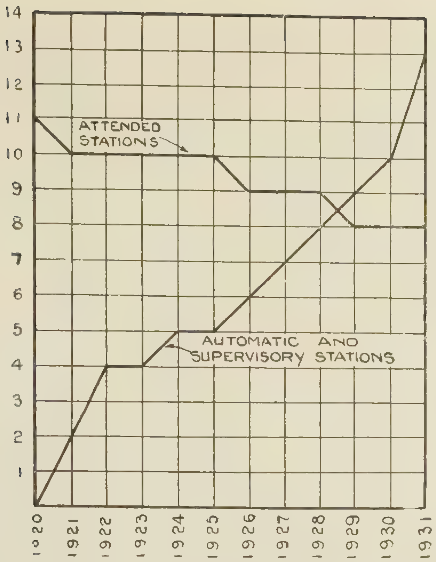


Fig. 3. Number of supervisory and automatic stations compared with attended stations

3. The contactor coils burned out repeatedly, and finally were rewound with a larger number of turns to avoid overheating.

4. Converter-bearing thermostats became inoperative due to warping of the fiber plunger rods.

5. The brush-lifting motor burned out, requiring replacement.

6. The brush-lifting mechanism gave considerable trouble, and had to be modified.

7. No little trouble was experienced with the arcing over of contacts on the polarized motor relay. These contacts had to be modified before the trouble was eliminated.

The two 1,100-kw. mercury-arc rectifiers manufactured by the Brown Boveri Company are fully automatic, the automatic features including (a) plant control whereby either unit may be made the leading unit while the other is switched in or out according to the demand on the station; (b) a-c. closing and reclosing whereby the circuit breaker connecting the rectifier transformer to the a-c. supply is controlled; (c) vacuum-pump control; and (d) the protective group. This rectifier equipment has given very satisfactory operation although some operating troubles were experienced when the apparatus was first installed. These were:

1. Insulator on excitation anode was found cracked due to incorrect size and improper packing.

2. Ignition coils burned out several times due to relay sticking, but this was overcome by modifying the relay.

3. Poor contact on control relay prevented the rectifier from being cut in.

4. Trouble on overload relay contacts prevented the second unit from coming in.

Supervisory Control Equipment

The Westinghouse high-speed, visual, supervisory-control system is an all-relay system embodying the principle of step-by-step synchronous selection. This system has been installed in four stations, the first having been installed six years ago, the second four years ago, and the other two, three years ago. This equipment although not entirely free from trouble has given satisfactory operation. In almost every instance, however, the troubles experienced are of minor nature, and usually are found to be due to contacts or relays requiring slight readjustment. Control-key contacts, battery equipment, and fuse troubles also contribute to faulty operation.

In the Danforth station 45 cases of relay troubles were reported in five years. Fourteen of these were due to latching relays sticking. Operating records of the other stations using the same kind of equipment, but of more recent date, do not show the latching relays to have given any more trouble than other relays.

The distributor-type supervisory-control system of the General Electric Company was installed in the Parkdale station in 1928. This was one of the early developments of supervisory control and uses a modification of the printing telegraph distributor and polarized relays to minimize the number of connecting line wires between stations. Due almost entirely to the distributor mechanism considerable trouble was experienced with this type of equipment.

The motor-driven distributors, one installed at each end of the control system, were operated continuously and had to be kept in synchronism if proper operation of the control system was to be obtained. Numerous faulty operations were experienced as a result of this part of the equipment getting out of order, and it was finally decided to change the system to the more recent development known as the synchronous-selector type of supervisory control. This new system, which replaced the distributor-type supervisory control in the Parkdale station, is essentially a direct system of control and indication employing the familiar type of rotary selector used for automatic telephones, which step in synchronism to transfer the control and indication line-wires from one circuit to another as selected by the dispatcher. This synchronous-selector type of equipment has been in operation since April 1930, and has given very satisfactory operation. Only two relay troubles have been experienced during the first eight months.

A cable system of supervisory control which was developed by the Toronto system for its own use is

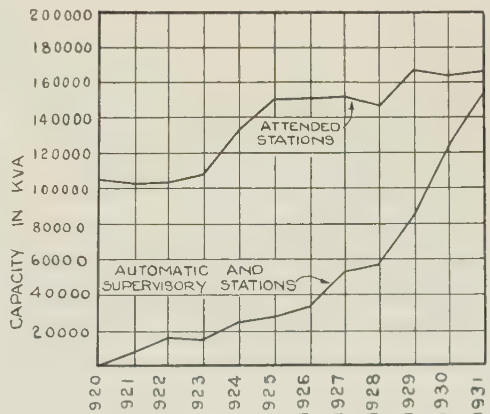


Fig. 4. Installed capacity of supervisory and automatic stations as compared to attended stations

Table I—Performance of Supervisory Equipment

Station	Type	Control positions	Months in service	Supervisory relay trouble	Control key trouble	Battery equipment trouble	Fuse trouble	Human factor	Line troubles	Outages due to supervisory trouble	No. of operations per year
Market	T.H.E.S.	30	114	4	4	2	5	1	None	1	100
Keele St	T.H.E.S.	17	102	3	2	2	1		1	1	175
Carlaw	T.H.E.S.	18	11	5	2	2	2		None	0	400
Danforth	W.E.&M. Co	50	60	45	2	5	2	3	None	8	3,000
Parkdale A	G.E.Co.	46	21	7*							
				98†	4	1		3	None	11	300
Parkdale B	G.E.Co.	46	8	2	0	1		2	None	2	325
Defoe	W.E.&M. Co	30	53	9	1	2	1	2	None	8	175
John St	T.H.E.S.	30	18	2	1		1	3	1	1	100
Wiltshire A	W.E.M.Co.	40	47	10	3		3	0	None	8	2,000
Wiltshire B	W.E.M.Co.	40	47	10	4	4	2	0	None	4	200

*Relays †Distributor

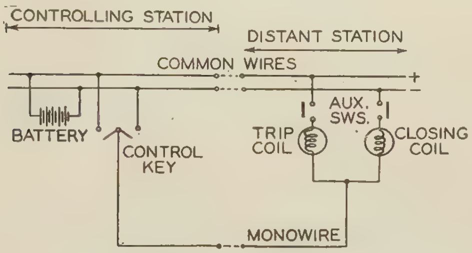


Fig. 5. Fundamental circuit of Monowire supervisory control scheme

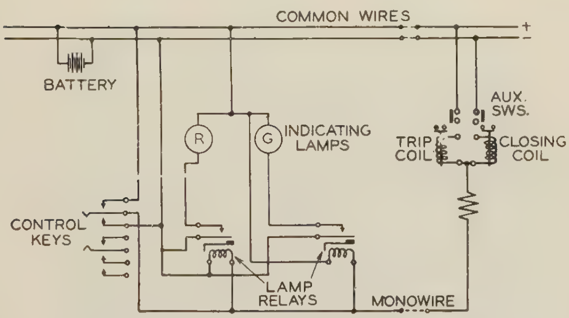


Fig. 6. Monowire scheme with indicating features

installed for four stations. It has been called the Monowire type of supervisory control, since in addition to two wires which are common to all control units it requires only one wire for each unit to be controlled. Control of the units and an indication of their operation can be secured by this system, simplified diagrams of which are given in Figs. 5 and 6. In complete commercial circuits, additional lines and safety features are added. Although the diagrams show control for one unit only the scheme may be extended to any number of units desired.

During the past ten years this system of control has given very satisfactory operation. There has been very little trouble with the switch operation, although a certain amount has been experienced with the signal devices. Most of the trouble was due to faulty relay operation. The relays used in this system are standard and have been tested under most severe operating conditions. Troubles have been due to a number of causes, such as residual adjustments, faulty contacts, loose nuts and screws, dirt, etc., all of a minor nature. A few sources of trouble have occurred with control-key contacts, battery equipment, poorly soldered joints, loose fuses, blown fuses, etc. Relay equipment purchased recently has given much less trouble than the earlier equipment, indicating that the manufacturers have overcome troubles experienced with the earlier designs.

This cable supervisory system finds its widest application where the distance between stations is short. The very satisfactory operation secured with this scheme has resulted in its being used on the Toronto system where the total cost of installation, including supervisory cables, was less than other schemes using synchronized switches at the sending and receiving ends. It is so much more simple and reliable than the other systems that its use seems justified wherever cost will permit.

Supervisory Automatic Control of a Generating Station

By
R. M. STANLEY
Fellow A. I. E. E.

Byllesby Engg. & Management Corp., Chicago

EIGHT hydroelectric units, each having a capacity of 13,508 hp., are installed in the Ohio Falls hydroelectric station at Louisville, Ky. Each generating unit is complete in itself. Waterwheel, generator, exciter, governor, electrical control, oil and water supply, oil circuit breakers, etc., are individual to each

From "Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control" (No. 31-109) presented at the A. I. E. E. summer convention, Asheville, N. C., June 22-26, 1931.

unit and all related unit auxiliaries are fed entirely from that unit.

An automatic electrical control unit and a hydraulic control unit are located near each generator. The electrical control equipment is similar to that used in other stations but is placed inside of a sheet steel cubicle located adjacent to the governor. For all units in the station, there is a centralized supervisory control switchboard of the miniature type located near the center of the plant, with a multi-conductor telephone cable between the miniature board and each generator control unit. The miniature supervisory board resembles in some respects a manually operated telephone switchboard. The arrangement of control keys and indicating instruments on 4-in. panels places the control of all generators, transformer banks, etc., within convenient reach of the operator.

The advantages of supervisory and automatic control have been demonstrated clearly during their three years of operation. With the miniature switchboard, the operator is at all times closer to indicating instruments, control switches, etc., and can give better and closer supervision to the operation of the equipment. This results in better voltage control, frequency control and division of load among the generating units. The supervisory control and automatic features give another distinct advantage in that there is a great saving in time during normal and emergency operation, and to a large extent human error is controlled. When urgently needed a hydroelectric unit can be brought to speed and synchronized in one minute, and additional units can be put on the bus in approximately 30-sec. intervals thereafter. Due to this speed, it has become the practise to carry less reserve steam capacity when hydro units are available.

There is a marked saving in labor costs since only one shift operator is required for the entire station. In addition, supervisory and automatic control made it possible to reduce the initial capital expenditure and to lower fixed charges.

The miniature board is no more costly to maintain than any other type of switchboard; in fact, a comparison with maintenance costs on a benchboard and vertical board with full-sized instruments, control switches, etc., at Waterside steam station indicates that the maintenance and inspection cost of the miniature switchboard and automatic equipment is less. As most of the equipment is enclosed in a practically dust-proof cabinet very little cleaning has to be done.

Scheme of Control

The general scheme of control is that the turning of a miniature control key or pushing of a button at the miniature supervisory board sets in operation automatic relays associated with the unit being supervised. These automatic relays, of the polarized type, function in a predetermined sequence for each desired operation, such as the starting or stopping of a generator, or connection of a transformer bank. A remote indication of the kilowatt load, reactive voltamperes, and voltage on each unit is given on miniature instruments. For the generators these are direct-connected to the instrument transformers, and on transformer banks, Selsyn type miniature instruments are used.

On starting a generating unit the supervisory operator turns a key which selects the proper bus and synchronizing method. He then pushes a button which

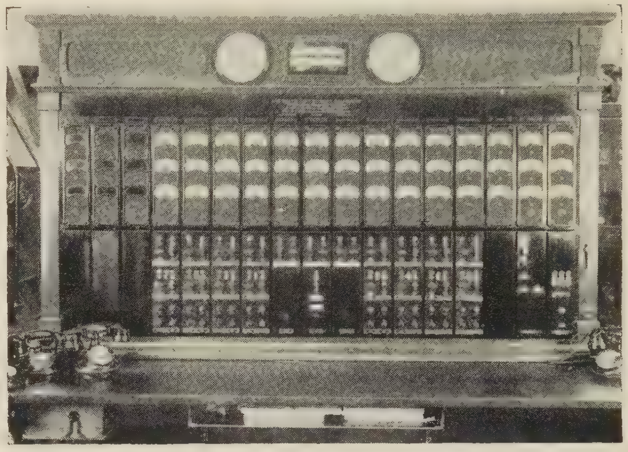


Fig. 7. Miniature switchboard for supervisory control of all generating units in station

gives the starting impulse to perform the following functions: maintain governor oil pressure; release brakes; open gates; apply generator field; energize governor motor from generator supply; start generator air-cooling system; and synchronize the generator to the bus selected. The supervisory operator may then regulate the load, voltage, and reactive voltamperes.

While in operation a full set of protective equipment is in use, and when the operator desires to shut down a unit the procedure is somewhat similar to that of starting. The equipment is tested only at intervals of three or four months when it appears necessary to clean the equipment.

Over a period of three years there have been no failures in the supervisory cable conductors. The push-button for control of load and voltage are similar in construction to telephone jacks, and have given very little trouble. A few cases of trouble were experienced with the rotating type keys used for giving the starting impulse, for selecting the proper bus and method of synchronizing, and for opening or closing oil circuit breakers. These troubles were all traced to insufficient spring tension, and no failures have occurred since proper adjustment. There has been only one unusual case of trouble with the polarized relays energized from the keys on the miniature board. This developed in summer when the relays were subjected to an ambient temperature of 50 deg. cent. and the impregnating

compound in the coils tended to vaporize and deposit on the armature, causing sticking in one position. This type of coil was changed and no further trouble was experienced. No cases of trouble have occurred with the sturdier contactors used for voltage and load control.

With the generator protective equipment very few difficulties have occurred. Practically all of these which could be attributed to manufacturing defects resulted because of vibration.

Synchronizing Methods

Generators may be synchronized to the bus by two methods; (1) through self-synchronizing equipment wherein the machine is brought up to speed, the armature is closed in on the bus, and the field applied instantly thereafter; (2) automatic synchronizing relays which approximate closely the manual method of synchronizing. The speed of the incoming machine is regulated to match that of the running machine and when the phase-angle between the voltage of the two machines is satisfactory, the machine is closed in on the bus.

Each method has its advantages. The self-synchronizing method is faster, requiring about one minute to bring a machine up to speed and synchronize; this is generally used when the system capacity is large and the head of the river is above 20 ft. Oscillograms taken during synchronizing indicate that the current in the armature varies from one and one-half to twice normal. This dies down rapidly and generally reaches normal value in ten cycles. At the Waterside steam station a slight dip in system voltage equivalent to about one volt on a 110-volt basis occurs. The "bump" given the system during these conditions therefore is found to be not objectionable and the self-synchronizing method is used whenever possible. It has a further advantage over automatic synchronizing in that it enables a generator to be pulled into step during periods of severe system trouble when the frequency is below normal. The automatic synchronizing equipment is used only when the output of the hydro station is small due to the low head. The majority of synchronizing operations with this equipment require from two to three minutes from the time the unit is started; but very exact synchronizing results.

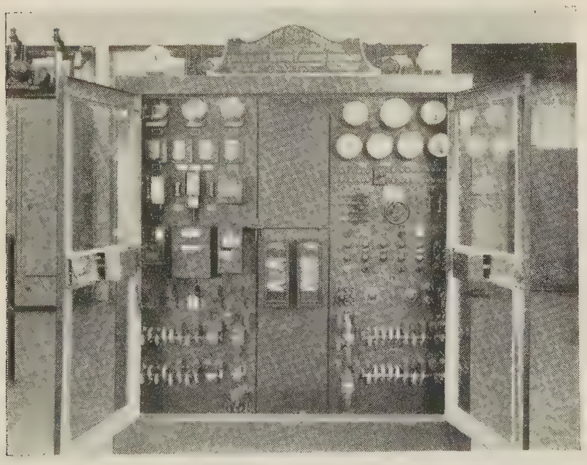


Fig. 8. Individual generating unit switchboard

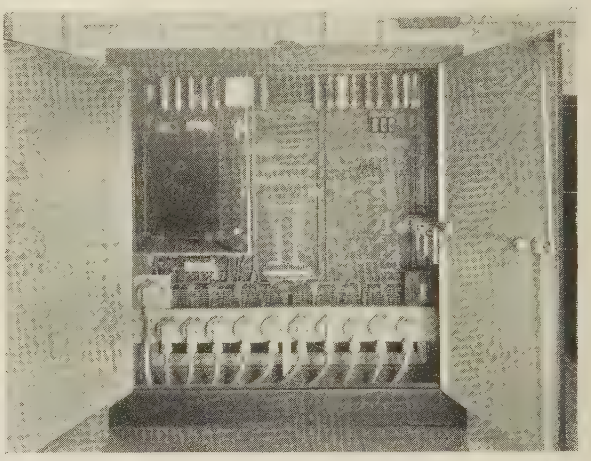


Fig. 9. Rear view of generator switchboard

To date there have been five system disturbances which resulted in the hydro station dropping load. These disturbances all occurred before the generators were equipped with self-synchronizing equipment; therefore, in cases where the automatic synchronizing equipment did not function rapidly enough, the operator put the machine on manually in order to save time. A maximum of four minutes was required to get the last generator on the bus. Now that the much quicker method of self-synchronizing is installed for all generators, it is being used almost entirely.

Each disturbance was caused by a short circuit of considerable magnitude, and when the circuit breakers opened, the overspeed of the generators and consequent rise of voltage was sufficient to operate the overvoltage protective relays, thus removing the generators from the bus and shutting the units down.

The operating experience obtained with the supervisory and automatic control at this station during the past three years indicates definitely the advantages of this combined system. The use of automatic devices has demonstrated its reliability, low cost of maintenance and inspection, the saving of time and operating expense, and the ease of supervision and operation. It is believed that in hydro plants where units are taken off and put on the bus frequently, this type of control equipment not only is superior to manually operated equipment, but that the plant will be operated with greater safety to equipment.

Communication in the New Waldorf Astoria

Said to be the most completely equipped hotel ever built, this new edition of a famous old hostelry contains the largest array of electrical program distribution equipment ever installed in one building. Included also in its communication system are approximately 3,700 telephones and 66 teletypewriters; 125 trunk lines connect the hotel with the telephone central office.

THE LARGEST program distribution and public address system so far brought together under one roof has been installed in the new Waldorf Astoria Hotel, recently opened in New York. Six separate channels are provided over which six different entertainment features may be distributed simultaneously both to the 1,940 private rooms and also to the many public rooms. This hotel occupies an entire block in the heart of the city and has a total height of 640 ft., including the 42 floors, and the two 100-ft. towers. It is considered to be the most completely equipped and most modern hotel yet constructed.

In addition to the program distribution facilities, the Bell system has arranged a communication installation which is said to be the most extensive ever placed into service in any hotel. Two groups of telephones have been installed, one to serve principally the hotel guests, the other to be used by the management for administrative purposes. To supplement the facilities for transmitting the spoken word, the hotel has been equipped with 66 teletypewriters. The entire communication system is served by 125 trunk lines from the telephone central office.

Program Distribution System

Features to be distributed over the six channels of the program distribution system may originate from any of the following sources:

1. Programs picked up by standard condenser microphones in any of the various public rooms.
2. Radio programs picked up by any of six Western Electric 10-A radio receivers.
3. Recorded programs reproduced on double turntable reproducer sets, of which two have been provided.
4. Wire line programs brought in from the outside.

Written especially for Electrical Engineering. *Not published in pamphlet form.*

A schematic diagram of the complete system may be seen in Fig. 1, all of the apparatus shown being housed in a control room on the sixth floor of the building. On the left may be noted the various program sources. Immediately to the right of these may be seen a bank of three-channel "mixers" and speech amplifiers. By means of these the input from as many as six microphones at one location may be blended together and amplified before going to the main amplifiers. Circuits are provided whereby the operator in the control room can communicate with an "observer" in any public room in which a program may originate.

For the six main amplifiers, one for each channel, Western Electric type 59-B units are used with the usual volume indicator, monitoring headset, and switching controls. The amplifiers operate entirely on alternating current, and possess practically a flat frequency characteristic between 20 and 10,000 cycles.

The power amplifiers consist of 31 Western Electric type 57-A units, 24 of which are used for guest room service, six for the public room circuits, and one for broadcast amplification. Each of these amplifiers has an undistorted power capacity of +32 db. above a zero level of 6 milliwatts. Means are provided for switching the output of these power amplifiers to the various circuits and for matching impedances.

Program circuits to guest rooms are distributed from a central distribution box through lead covered cables to outlet boxes in three riser shafts, the first extending the full height of the building, the second to the 21st floor, and a third to the 17th floor. Three 152-pair cables of No. 16 B&S gage wire are installed in these shafts, two in the first and one in the second, with a similar 102-pair cable in the third shaft. Distributing boxes are provided on the various intermediate floors wherein wires from the cables terminate in sealing chambers. From these boxes circuits are distributed throughout the floors with a maximum of four groups connected to any one riser pair and a maximum of twenty rooms connected to any one group.

For the private rooms special loudspeakers were developed which can be plugged directly into the program distribution outlets. Each speaker is provided with a six-channel selector switch and a volume control. The energy level to the speakers is held in the main control room to such a value that the maximum output from any speaker will not be sufficient to annoy guests in adjacent rooms.

One of the outstanding features of the entire installation is the flexibility of equipment and complete interchangeability of all major elements. All units such as radio receivers, main amplifiers, power amplifiers and distribution units terminate in jacks so that they can be "patched" into a variety of different positions in the circuits. In addition the system has been so designed and laid out that maintenance problems will be simplified as much as possible and that in the event of trouble the affected portion of the system can be segregated readily.

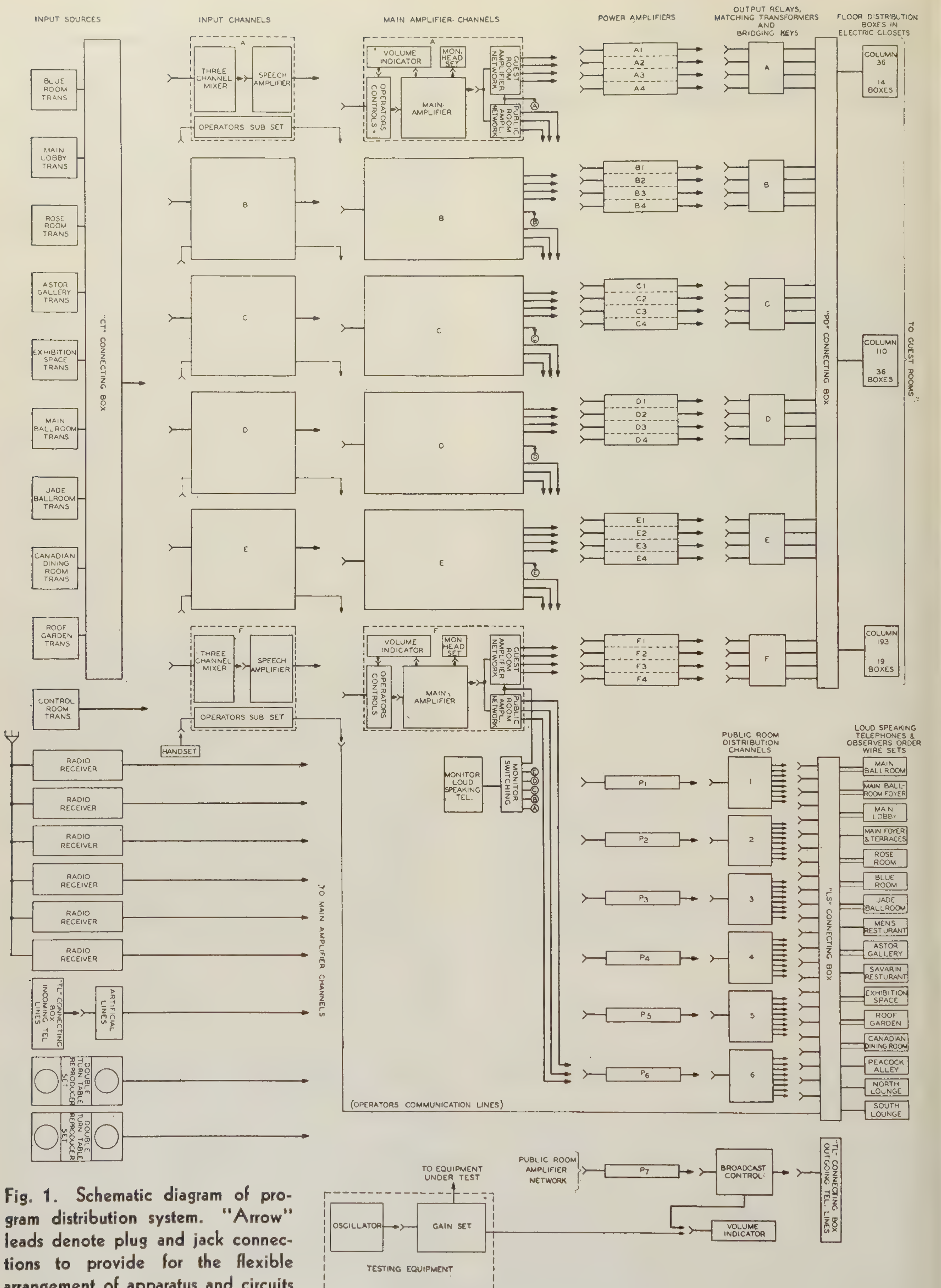


Fig. 1. Schematic diagram of program distribution system. "Arrow" leads denote plug and jack connections to provide for the flexible arrangement of apparatus and circuits

The entire program distribution system as well as the radio distribution system described in the following paragraph were designed by Bell Telephone Laboratories. The equipment was furnished by the Western Electric Company.

Radio Distribution System for Tower Suites

In addition to the main antenna serving the six radio receivers of the program distribution system, two other antennas have been installed between the hotel's two towers. Specially shielded radio frequency distribution circuits connect each antenna to 69 tower apartments so that occupants of these suites may operate their own individual radio receivers therein. To operate such a large number of miscellaneous receivers from a single antenna without interference presented a difficult problem, the final solution of which consisted of supplying a separate radio frequency amplifier for each individual receiver. The circuits are so arranged that these coupling amplifiers are controlled by the same switch which controls the individual receivers themselves. Thus none of the amplifiers is turned on when not in use.

Power Supply

Since all electric power for the entire hotel is supplied from a d-c. system, special arrangements were necessary to furnish the program equipment with alternating current. For this purpose two 15-kw. motor-generator sets were installed in the power room on the seventh floor of the building, one being for regular use and one held as a spare. These are provided with automatic speed control to maintain proper frequency (60 cycles) and may be started, stopped, or otherwise controlled from either the power room or the control room on the floor below. These units are large enough so as to assure close speed and voltage regulation, and an unusually undistorted voltage wave under full system load.

Other Equipment

While the program and radio frequency distribution systems perhaps constitute the most novel features of the whole communication system, the telephone and teletypewriter systems are just as complete. They embody the latest developments in telephone engineering adapted to the needs of a modern hotel. The telephones may be divided into two main functional groups: one a manually operated system to serve the guests of the hotel, the other a dial system for use by the management.

About 3,200 telephones are provided for the use of guests in addition to the private telephones in the tower apartments served by individual lines from the central office. Of this total number about 2,600 are permanently connected extensions from a 28-position private branch exchange switchboard. The remaining 600 are portable instruments and may be conveniently plugged into auxiliary outlets with which some 600 of the rooms are equipped.

The telephone group for use by the management includes dial equipment sufficient to serve about 500 telephones in the executive offices, corridors, pantries, and other quarters occupied by the hotel personnel. These telephones may be interconnected with any of the manually operated instruments through the private branch exchange switchboard.

The teletypewriter installation comprises 66 machines, these also being divided into two main groups. The first group of these will be used primarily for transmitting to employees in every department concerned with their service, information pertaining to the arrival, change and departure of guests. The second group is provided with auxiliary order-taking equipment so that operators of the machines may take messages intended for guests directly from persons calling, and transmit them by wire to the guest's floor to be delivered when he returns, or to the bell captain so that the guest may be paged. With this system written messages may be transmitted from any of the sending machines in the telephone room to receiving machines accessible to the bell captain, porter, tower housekeeper, room clerk, valet, or to other receiving machines located on 22 floors, and in the tower office.

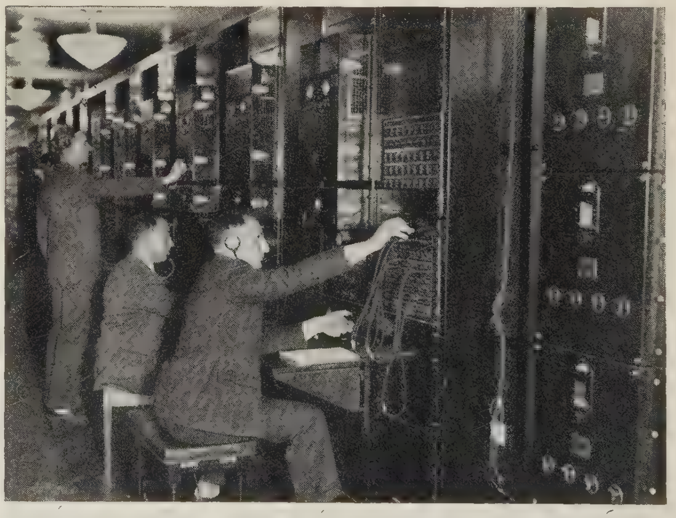


Fig. 2. General view of control room showing some of the 22 racks of amplifiers and other program equipment. Three of the six rack-mounted radio receivers may be seen at the right

Although not strictly concerned with communication equipment it may be mentioned that sound picture apparatus of the theatrical type has been installed permanently in the grand ballroom. Also one portable machine has been provided with which talking picture entertainment or lectures can be taken to any of the smaller public rooms.

Corona Versus Conductor Surface

Tests show that thin coatings of some materials reduce the corona losses from high voltage conductors, and that equal losses may be expected from weathered copper and aluminum wires of the same diameter. This investigation was suggested by previous tests (1930) made at the Ryan Laboratory, Stanford University; this earlier work indicated a temporary reduction in losses after the conductors had been cleaned.

By
W. D. WEIDLEIN   Black & Veatch
Kansas City, Mo.

IN THE INVESTIGATION described here, corona loss measurements were made on copper and aluminum wire (1) as received from the manufacturer (2) with different surface treatments and (3) after weathering. Test equipment was arranged as shown in Fig. 1 and was similar to the set-up used in the previous tests made in the spring of 1930 at the Ryan Laboratory, Stanford University. Test specimens consisted of 50-ft. lengths of No. 2 B&S gage solid conductors, supported 8 ft. 6 in. from the ground. The sag at the middle of the specimen was less than 2 in. in all cases with clearance in all other directions greater than 15 ft. In some of the tests, specimens were coated with different materials. The maximum increase in specimen diameter resulting from such treatment, however, was only 0.001 in., which would cause but very little variation of corona losses.

Insulator loss on the outer end is included in all results, but is negligible in amount; for comparative results this insulator loss does not enter in, since it was present in all tests. Insulators at the wattmeter end of the specimen were shielded so that their losses would not enter into the wattmeter reading. All tests were made within the laboratory and under as nearly similar conditions of temperature, humidity, and barometric pressure as possible.

In all tests after the specimen had been treated, the procedure followed was first to build up the specimen voltage to 100 kv. The loss at this voltage then was read, after which similar readings were taken for sucessively lower potentials at from 5-kv. to 2.5-kv. intervals, depending upon the rate of change in loss.

A comparison of losses from aluminum and copper conductors is shown in Fig. 2. The shape and shift of the curves between values of from 72.5 to 80 kv. should be noted. Joffe's theory that the resistance of a polarized layer decreases when the e.m.f. produced by polarization due to space charge exceeds 2,000 volts, ("The Physics of Crystals") is a very plausible explanation of this action. No doubt high loss from the copper conductor as received from the manufacturer is due to residue left from the "pickling" process or from drawing.

In Fig. 4 the first run (curve a-D) was made on a conductor coated with a thick film of linseed oil brushed on and dried. This wire then was cleaned and wiped once over its surface with a cloth soaked in linseed oil. A complete film was not formed, which accounts for the weathering and higher losses after drying. Curve 3-D gives the loss after wiping a second film onto the wire, and shows a decrease in losses at potentials near 75 kv. Apparently there may be some justification for the theory that with a complete thin film covering, ionizing velocities of electrons cannot be attained within the film because of an insufficient ionizing potential fall. Space charge then increases to a point where its leakage resistance starts to decrease, thus permitting a greater potential fall throughout the adjacent air and causing a sharper rise in corona loss.

In Fig. 6 curves are shown for copper and aluminum conductors, cleaned, and then suspended open to weather for about one month. These indicate equal losses for the two materials over the range tested.

Curve 3-F of Fig. 7 gives the results of a test made on a copper conductor coated with a smooth film of copper oxide formed by heating. While at 21 kv. corona was observed around this wire, no streamers formed over the range of voltage tested up to 150 kv. r.m.s. Other curves of Fig. 7 show the losses from a conductor after being heated in acetylene gas. Upon removal from the gas a granular deposit of carbon covered the conductor; the losses were as plotted in curve 1-N. After this carbon was rubbed off the losses were as plotted in curve 2-N. An interesting point in this connection was that carbon had been deposited to a depth of 1/16 in. into the conductor.

Conclusions

1. Thin films decrease corona loss.

Thin coatings of certain materials are effective in decreasing corona loss from high voltage conductors, whereas thicker films will increase such loss. Such a film may be the polished surface of a metal itself, or the formation of a film by materials which flow readily and solidify with a glaze or a crystalline surface.

2. Same losses for weathered copper and aluminum.

Corona losses from copper and aluminum conductors are practically equal after weathering, providing any detrimental effects remaining after drawing have been eliminated.

3. Favorable corona loss reduction indicated.

Favorable results in the reduction of corona loss are illustrated by the shape and shift of the curves in some cases. This conclusion is supported in several tests by deviation of the curves to the right from a straight line from high to low values of loss, and at voltages of from 72.5 to 80 kv. for the size of conductor used in these tests.

Based upon "Corona Energy Loss" (No. 31-139) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

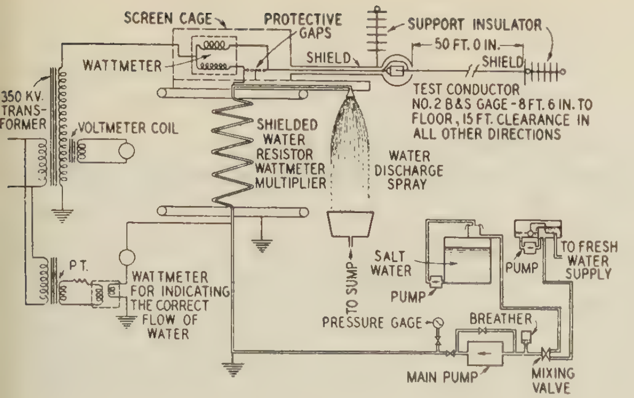


Fig. 1. (Left) Schematic diagram of test set-up

Fig. 2. (Right) Comparative tests on copper and aluminum specimens

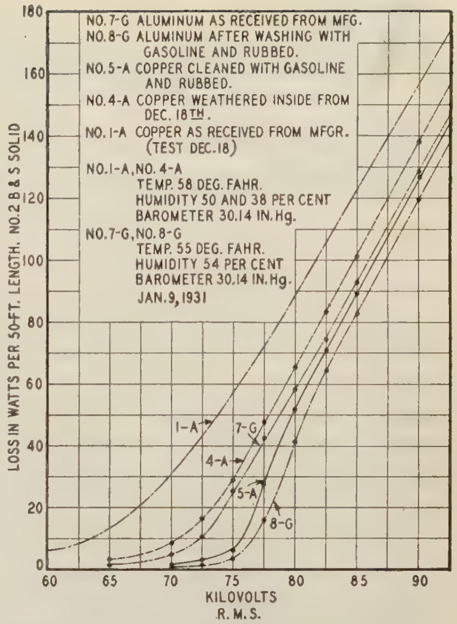
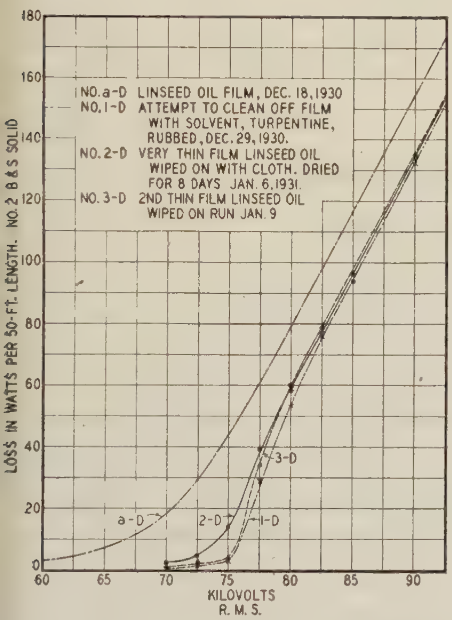
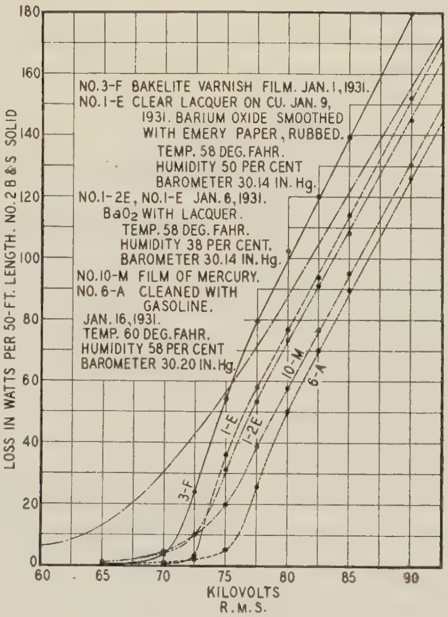


Fig. 3. (Below) Effect of linseed oil films of different thicknesses

Fig. 4. (Below) Effect of thin film coatings of different materials





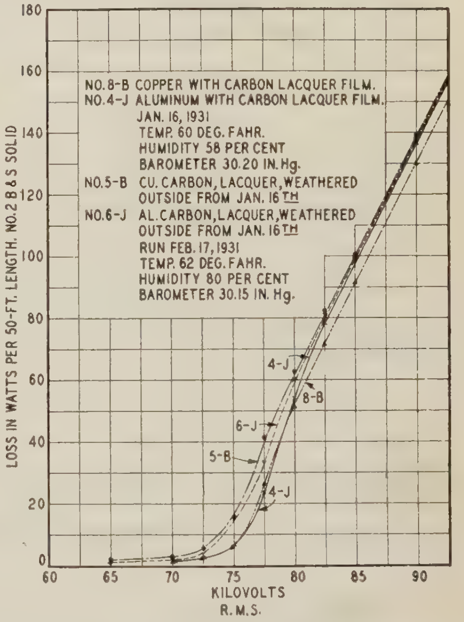


Fig. 5. (Above) Films of same material on both copper and aluminum

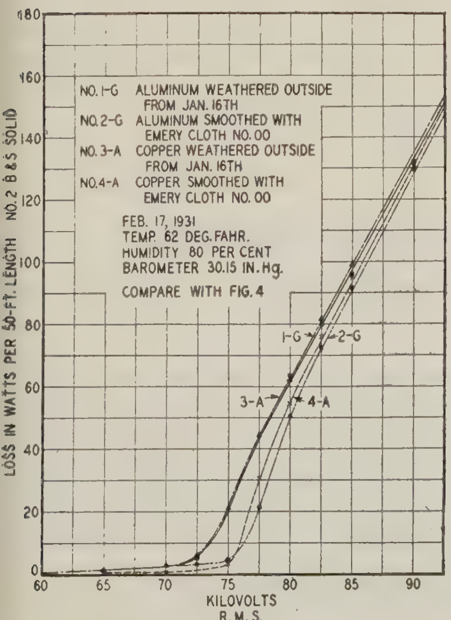
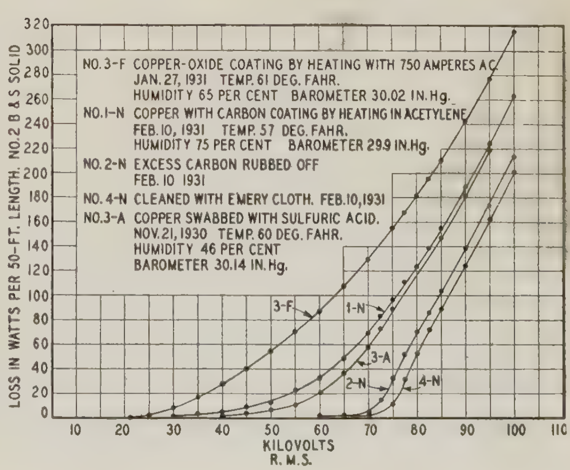


Fig. 6. (Left) Copper and aluminum conductors, first cleaned and then weathered, show equal losses

Fig. 7. (Right) Effects of oxide and carbon coatings on copper specimens



Abstracts

Of Papers Presented at the Kansas City District Meeting

INTERPRETIVE abstracts of all papers presented at the A.I.E.E. Kansas City District meeting (October 22-24, 1931) are presented herewith, excepting only those papers already published in this or preceding issues of ELECTRICAL ENGINEERING. Members vitally interested and wishing to obtain immediately pamphlet copies of any of these papers are requested to use the order form appearing on p. 920 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Electric Arc Welding in Building Constuction

By P. N. Vinther[1]

ELECTRICAL ENGINEERING for October 1931, p. 785-7, contained an article based upon this paper. (**A.I.E.E. Paper No. 31M8**)

Effect of Wave Form on Operation of Induction Relays

By P. H. Robinson[2]

INDUCTION type relays will of course operate at their intended current values and time settings only when the shape of the current wave applied during a fault is similar to that of the test wave. The shape of the current wave in the relay during fault is dependent upon the wave form of the fault currents and voltages, and the characteristics of current transformers and secondary circuits.

Although protective relays previously have been applied upon the basis that the wave shapes throughout were sinusoidal, and that the speed of operation of relays under test and under actual system faults for similar conditions were the same, the complexity of relay problems recently encountered requires a more careful consideration of wave form.

A detailed study indicates that the wave form of fault currents need be considered only in special cases such as the application of high-speed relays. However, even with ordinary-speed relays, current transformers may produce distortion of the secondary current during fault, and the use of such devices as auto-transformers, testing transformers and phantom loads in the relay test circuits often result in extreme distortion. In general, distortion of the current wave results in slower relay operation.

Circuits for secondary tests should be so proportioned as to give a current wave as near a sine form as practical. Air core inductance coils are very effective in correcting distorted wave forms arising from the characteristics of the test circuit. Primary test circuits having carefully selected equipment is of great value in obtaining over-all tests of current transformers, secondary connections and relays. (**A.I.E.E. Paper No. 31M15**)

A Telegraphic Pilot-Wire Relay System

By C. H. Frier[3]

PUBLISHED in full in ELECTRICAL ENGINEERING for October 1931, p. 824-6. **Pamphlet copies not available.**

Calculating Load Division in Distribution Systems

By C. T. Almquist[4]

A COMPARATIVELY simple and convenient method is available for solving the division of current in the various sections of an electrical network and obtaining the voltages at the different load points. The method consists essentially of the application of Kirchoff's laws to the solution of a network, the departure from the usual procedure being that instead of solving a number of simultaneous equations, the problem is handled in steps by the superposition of currents. The idea of a circulatory current is introduced when any change in the system is made by a closure between two points in the existing system.

While the method outlined is a step by step method, each step in the solution is of value in that it indicates the results obtaining for the different possible conditions of operation of the system. The application of the method is to the loop and network circuits encountered in power distribution. By its use relatively simple network circuits may be solved without the use of a calculating board. (**A.I.E.E. Paper No. 31M9**)

Overvoltage on Transmission Systems Caused by Dropping Load

By E. J. Burnham[5]

THE INCREASE in voltage resulting from total or partial loss of load is especially undesirable on waterwheel driven generators because of their regulation characteristics and the fact that they are frequently connected to long lengths of high tension transmission line. The charging current of such lines results in a further increase in voltage. Although various

1. Dallas Power & Light Co., Dallas, Texas.
2. Houston Lighting & Power Co., Houston, Texas.
3. Oklahoma Gas & Electric Co., Oklahoma City.
4. University of Oklahoma, Norman, Oklahoma.
5. General Electric Co., Schenectady, N. Y.

types of relays have been used to trip the generator on the occurrence of excessive voltage or speed, a more desirable method of limiting the voltage is by the use of generator voltage regulator acting in the generator or exciter field circuit.

Tests have been made on a 47,000-kva. generator making use of a newly developed generator voltage regulator with a wheatstone bridge type of main exciter field rheostat, so adujsted that the exciter voltage may, if necessary, be reduced to a slightly negative value, thus quickly reducing the generator field current and limiting the generator armature voltage. This equipment ordinarily functions to maintain the alternating voltage normal, but at the same time is constantly ready to prevent the voltage from reaching dangerous values which would overstress the insulation of generators and connected apparatus at such time as loads might be dropped on the generating unit. The use of such equipment has made it possible to design lightning arresters and protective apparatus to give better protection.

An alternative method which is less expensive and which may be applied to older machines where it is not desirable to change the exciter to a quick response type, consists of automatically inserting a block of resistance in the alternator field circuit. This method, although not giving accurate regulation, has been found effective in keeping the voltage within desired limits when load is lost. (**A.I.E.E. Paper No. 31-140**)

Backfires in Mercury Arc Rectfiers

By
J. Slepian[6]
L. R. Ludwig[6]

A COMPREHENSIVE abstract of this paper was published in ELECTRICAL ENGINEERING, October 1931, p. 793-6. (**A.I.E.E. Paper No. 31-132**)

Impulse Voltage Tests on a 4.8-Kv. Distribution Substation

By
H. W. Collins[7]
E. E. Piepho[7]
J. J. Torok[6]

DISTRIBUTION lines from ungrounded 4,800-volt substations of the Detroit Edison Company commonly have several hundred feet of three-phase underground cable between the overhead lines and the station, voltage regulators being connected between the bus and the station end of the cable. Although lightning arresters are connected at the substation bus and at the junctions of the overhead lines and entrance cables, a number of flashovers due to lightning voltage have occurred, consistently between the line terminal of the regulator and the station end of the entrance cable.

As the result of a series of impulse voltage tests, two forms of protection were found to be effective in preventing the surge voltage rising to values sufficient to break down the entrance cable or cause flashovers at the station end. Low voltage lightning arresters shunted across the regulator series windings operate in series with the bus arrester and limit the rise of voltage on the line side of the regulator to the sum of the breakdown voltages of these two sets of arresters. The second method, and the one which is more desirable because it insures a lower voltage at the substation end of the cable, is to connect lightning arresters at this point. They limit the voltage on the substation pothead and on the regulator; and, acting in combination with the arresters on the bus and at the outside end of the cable, limit the voltage in the cable to the drops across the arresters. (**A.I.E.E. Paper No. 31-133**)

Interconnection of the 25- and 60-Cycle System of the Union Electric Light & Power Co.

By
L. V. Nelson[8]
E. L. Hough[8]

FREQUENCY conversion was determined as the best means of supplying differences between the 25-cycle and 60-cycle loads and generating abilities of the Union Electric Light and Power Company system. The hydroelectric plant at Keokuk, Iowa, was developed as a 25-cycle run-of-river plant to supply the 25-cycle load in that vicinity and to transmit power to St. Louis, where the load is largely 60 cycles. Various possibilities in 25-cycle and 60-cycle steam and hydroelectric plants presented themselves but a frequency converter was decided upon as the most desirable.

After a careful study of the five types of machines available, it was decided to purchase two variable ratio synchronous induction converter sets, each capable of transmitting 20,000 kw. in either direction, with variation from normal frequency of ½ cycle in either direction on each system.

The machines are of the six-bearing horizontal type with provisions for movement of stators to permit easy maintenance or repair. A split coupling is provided between the two main machines and the starting motor and d-c. exciters are on the 60-cycle end to permit the operation of the latter as a synchronous condenser independent of the 25-cycle machine.

It has been found that the inherent ability of the machines to change load gradually with system speed changes has been of marked benefit in stabilizing the systems. The 60-cycle machines are equipped with high speed excitation systems to hold the voltage within narrow limits, and the corrective capacity in the induction units exerts a remarkable stabilizing influence on the 25-cycle voltage. (**A.I.E.E. Paper No. 31-137**)

Automatic Control for Variable Ratio Frequency Converters

By
E. K. Shively[8]
G. S. Whitlow[9]

AUTOMATIC switching equipment for the control of two 20,000-kw. frequency changer sets using the Scherbius method of load and power-factor control has been in successful operation at the Page Avenue station of the Union Electric Light and Power Company of St. Louis for almost a year.

The switching equipment is designed so that the starting, synchronizing, voltage control, loading limiting features, and protective devices are completely automatic. The performance of this equipment during all sorts of system conditions during the past year has demonstrated the feasibility of automatically controlling large frequency changer sets. The stabilizing effect of the 60-cycle high speed excitation system on the voltage during system short circuits and the accuracy and speed of the 25-cycle synchronizing operation are of special interest. Although manual synchronizing of the 25-cycle unit is difficult because of the complex character of the excitation system and the constantly

6. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
7. Detroit Edison Co., Detroit, Mich.
8. Union Electric Light & Power Co., St. Louis, Mo.
9. General Electric Co., St. Louis, Mo.

changing value of slip frequency, this operation is performed automatically in a very short time and with no interchange of power between the two systems. **(A.I.E.E. Paper No. 31-136)**

Forecasting Population for Engineering Purposes

By J. N. Hoben[10]

ENGINEERS and persons responsible for the management of engineering projects have a common interest in problems of forecasting population growth and market demands. The soundness of engineering projects depends upon their capacity to fulfil a real demand. Unsoundness or even failure may result from planning and designing engineering projects without regard to industrial and population trends. Similarly city planning, housing and home building projects, educational and social programs of various kinds, ordinarily should be based upon the number of people to be served at some future date and their economic and social characteristics.

Population forecasts, when carefully and intelligently made, serve a valuable purpose in helping to direct the employment of labor and capital to places or projects where they are most needed. What will most probably occur is always the first consideration in population forecasting. Sound forecasts cannot be made to rest upon a local point of view; national factors are always involved, frequently international. In boom periods it is necessary to guard against the tendency to overestimate, while the reverse is true of dull periods. Because of the fundamental influence of economic and geographic factors in determining the population growth of cities or regions, the economic survey is invaluable in determining the probable future number of people in a particular city or region, and their social and economic characteristics. Meticulous precision is impossible in making long range population forecasts, but it is both possible and practicable to obtain a valuable working knowledge of conditions in the future. **(A.I.E.E. Paper No. 31-138)**

Advance Planning of Long Distance Telephone Facilities

By C. C. McFarland[11]

THE RAPID increase in the size and complexity of the toll plant during recent years has emphasized the need for careful advance planning. This involves the development of an ultimate plan which indicates the most economical and desirable toll plant arrangement some 15 years in the future.

In developing an ultimate plan, estimates of future traffic and the corresponding circuit requirements are of great importance as are likewise the classification of the various towns and exchanges into tributaries, toll centers and switching points. Several possible arrangements of plant which will provide for the estimated circuit requirements and meet the service standards at the ultimate period are studied. Judgment must be exercised in deciding on the most desirable ultimate plan, due weight being given to such factors as cost, flexibility, and protection service.

Advance planning also is necessary in connection with individual projects involving additions and extensions to the toll plant particularly for the projects involving commitments for a number of years in the future. Several feasible plans of providing the plant are studied, the ultimate being used as a guide in setting up intermediate plans. Cost studies over a period of 5 to 15 years are made to determine the most economical scheme. **(A.I.E.E. Paper No. 31M14)**

10. Southwestern Bell Telephone Co., St. Louis, Mo.
11. Southwestern Bell Telephone Co., Kansas City, Mo.

Tape-Armored Telephone Toll Cable

By C. W. Nystrom[10]

BURIED tape-armored cables possess several advantages over cables carried on pole lines or in underground conduit:

1. Easements for buried tape-armored cable on private rights-of-way may sometimes be obtained more cheaply than for pole lines, as the use of the land for ordinary agricultural activities is not disturbed.

2. Induced currents from paralleling power lines are appreciably less than in unarmored aerial or underground cables, due to the shielding effect of the steel tapes.

3. Cable may be laid to follow the contour of rough country and have sharp bends to avoid obstructions, while conduit must have a fairly even grade and long radius curves to permit cable being pulled through it.

4. Manholes are required at spacings of from 500 to 700 ft. if conduit is provided, while with tape-armored cables, manholes may be omitted except at loading points which normally occur at 6,000-ft. intervals.

On the other hand, as tape-armored cables are buried directly in the earth, the location and repair of troubles are generally more difficult and more expensive than for aerial cables. However, improvements in methods for maintaining buried cables should reduce such costs, and in any event the amount of trouble per cable mile may be expected to be much less than on aerial cables, because of their security from fire, storm, and bullets.

Tractors, plows, trench backfillers, and other cable laying equipment have been developed. As a result tape-armored cable can be laid at a cost only slightly greater than that of aerial cable on pole lines, and developments now under consideration promise a rather substantial reduction in the cost of buried cable. **(A.I.E.E. Paper No. 31-134)**

The Time Factor in Telephone Transmission

By O. B. Blackwell[12]

FOR ORDINARY distances of telephone communication, the speed of transmission can be considered as instantaneous. The increasing use of long distances for commercial telephony, however, has introduced time problems in telephone transmission which are of considerable technical interest and difficulty. Although a number of papers have been presented on this subject, none seems to have given a general over-all picture.

In actual telephone circuits the speed of transmission is reduced from the speed of light by the impedance of the circuit, and varies considerably in different circuits. Five different types of problems in telephone communication are introduced. First, conversation may be slowed down by the time interval between the formation of a sound by the speaker and its reception by the listener. In two-way conversation this may become important as it causes a delay in reply. Second, differences in the speed of transmission of the frequencies which make up speech may produce peculiar distortions which cause considerable interference. Third, echo effects may arise from the reflection of energy at points of irregularity, particularly at the end of the circuit. These echoes have the greatest effect on the talker who may have an uneasy feeling that the distant party wishes to break in on the conversation. Fourth, the voice-operated devices which are sometimes connected in the circuit, and which overcome echoes by rendering inoperative transmission in the opposite direction, may result in a delay in transmission and introduce other serious difficulties. The fifth factor is that of

12. American Tel. & Tel. Co., New York, N. Y.

fading, which although not included in this discussion may result when there is more than a single path between the sending and receiving ends of a circuit. **(A.I.E.E. Paper No. 31-135)**

Lightning Disturbances on Transmission Lines

By
D. C. Jackson, Jr.[13]
R. W. Warner[13]

MOST OF THE more important studies of lightning disturbances on transmission lines have been confined to steel tower lines of 110 kv. and above. A field investigation of the effect of lightning on 33-kv. and 66-kv. transmission lines on wood poles is now being carried on, the preliminary investigations having been completed.

Data have been compiled showing the direct lightning hits and flashovers per pole in the Mississippi and Missouri River valleys. These indicate for example that guyed poles are more subject to disturbances than unguyed poles, and that corner poles also are more frequently affected. It was found that in the case of 66-kv. lines practically two-thirds of the guyed poles were hit or flashed over, whereas only about one-half of the guyed poles on the 33-kv. lines experienced lightning troubles. The proportion of unguyed poles affected was practically the same for both voltages.

The data indicate that there is little difference between the amount of lightning trouble experienced by poles in rolling country and by those in flat river bottoms. It is stated that whether a pole stands on the crest of a hill, on a slope, in a valley, or on open low land has little effect on the number of lightning disturbances. It is hoped that the continuance of this investigation will produce definite explanations of the causes of the phenomena observed. **Pamphlet copies not available.**

Corona Energy Loss

By
W. D. Weidlein[14]

PRACTICALLY the full text of this paper is published in this issue of ELECTRICAL ENGINEERING, pp. 898-900. **(A.I.E.E. Paper No. 31-139)**

Application of Primary Distribution Fuses

By
F. E. Sanford[15]

THE FUNCTION of the primary fuse is to clear short circuits, and to minimize disturbances to the system at times of fault. Continuity of service requires that short-time overloads should not cause primary fuses to blow, whereas fire hazard requires that fuses for secondary windings operate on an overload basis. The proper application of primary fuses is dependent upon the determination of the available short-circuit current as well as the value of load current. Another factor which must be given consideration is coordination of fuse and relay time-current characteristics to insure isolation of the fault at the fuse point rather than by the main feeder switch. Minimum time of operation should be sought in the selection of fuses, both to provide maximum flexibility in relay settings and to give minimum system disturbance. The time required for a fuse to blow in the short-circuit current range is more important than at the one or five minute points.

To be consistent with the rating of other electrical equipment, fuse ratings should be based upon their continuous carrying capacity. Ratings on some other basis are likely to cause confusion, and to make an accurate comparison between different types of fuses difficult. Consistent ratings also would facilitate interchange of fuses of different types. **(A.I.E.E. Paper No. 31M10)**

The Expulsion Fuse

By J. Slepian[6]
C. L. Denault[6]

THE EXPULSION fuse is an extremely simple device used quite extensively for interrupting a-c. circuits of moderate voltage and power. In spite of its apparent simplicity and widespread use, the principles upon which it functions are not at all generally understood. Comparisons of interrupting capacities of a soapstone fuse tube and a fiber fuse tube, support the view that the expulsion fuse depends upon the gas blast produced by rapid decomposition of fuse tube material under the heat of the arc. The effectiveness of the gas blast is stated to be due to the high degree of turbulence it introduces into the confined arc space.

The voltage interrupting capacities *versus* ampere capacities for a fiber tube and for a boric acid lined tube have been obtained experimentally, and it is found that the curves for boric acid lie much higher than for fiber. The characteristics were found to depend very materially upon the number of half cycles of arcing. Also it has been found that the circuit voltage which can be interrupted rises rapidly as the size of tube is decreased.

An interesting development of the expulsion fuse is the use of flame suppressors for deionizing the issuing flame. It has been shown that by introducing means for condensing the water vapor, the boric acid lined tube may be completely closed without the development of excessive pressure. In fuse design, consideration must be given to insure that the gas generating materials which aid in arc extinction will withstand the full circuit voltage with the passage of only small current, even when heated by the arc. **(A.I.E.E. Paper No. 31-141)**

Fuse Cut-Outs—Their Design and Application for A-C. Distribution Circuits

By
E. G. Newton[16]

MANY NEW developments to meet modern requirements have been applied to the renewable expulsion-fuse and oil-fuse cut-outs for a-c. distribution systems of 15,000 volts and below. While there are several different types of fuse cut-outs, the universal design problem is the interruption of an arc formed when the current carrying element melts. Both expulsion-fuse and oil-fuse cut-outs depend for this interruption upon the gas pressure generated by the current in the arc.

Three factors, circuit voltage, load current, and fault current govern the proper selection of fuse cut-outs and fuse links to meet the different service requirements. These factors are shown to have a relationship necessitating equal consideration in order to secure safe and reliable operation. Coordination also must be secured with other apparatus on transmission and distribution systems. Investigations now being made on the effect of power factor on arc interruption may have an important bearing on the future design of fuse cut-outs. **(A.I.E.E. Paper No. 31M11)**

13. University of Kansas, Lawrence, Kansas.
14. Black & Veatch, Kansas City, Mo.
15. Union Gas & Electric Co., Cincinnati, Ohio.
16. General Electric Co., Pittsfield, Mass.

News
Of Institute and Related Activities

Thomas Alva Edison—
February 11, 1847-October 18, 1931

BRINGING to a close one of the most colorful careers in history, Thomas Alva Edison, indefatigable promoter of the incandescent electric lamp, quietly breathed his last at 3:24 a. m. October 18, 1931, almost exactly 52 years after his invention of that lamp. He died at "Glenmont" his West Orange (N. J.) home in which he has lived since 1886. Apparently convinced for some weeks that his many sided life work was at an end, he is reported as having expressed a feeling of "inadequacy" for the continuation of the tasks to which he has devoted his best efforts during his allotted span of years.

Thomas A. Edison's characteristic, clear cut signature occupies a prominent place upon the original call issued in the spring of 1884 for the organization meeting of the American Institute of Electrical Engineers. This historic document, which occupies a conspicuous place in the members' room at Institute headquarters in New York, stated that "it seems probable that the persons who are interested in electrical, scientific, educational, manufacturing, telegraphic, telephonic, and like concerns, as well as the users of electrical appliances generally, will find it to their advantage, personally and collectively, to establish, support, work for, and generally aid our proposed Society."

Edison not only was one of the organizers of the Institute, but at its first election of officers, May 13, 1884, he was elected a vice-president. Thus, while electricity surely was in its infancy, Edison was actively interested in creating an organization the objects of which were to be as they still are as stated in its Constitution "the advancement of the theory and the practise of electrical engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members."

Edison Medal Established

In recognition of the inspiration to workers in the fields of engineering and science as provided by Edison's spirit and character in his life work, the Edison Medal was established in 1904 by an organization of associates and friends of Edison, "for the purpose of appropriately recounting and celebrating the achievements of a quarter of a century in the art of electric lighting with which the name of Thomas Alva Edison is imperishably identified. The A.I.E.E., in response to an invitation, undertook the responsibility of making the awards of this gold medal which its sponsors designated should "during the centuries to come serve as an honorable incentive to scientists, engineers, and artisans, to maintain by their works the high standard of accomplishment set by the illustrious man whose name and features shall live while human intelligence continues to inhabit the world." The first award of this medal was made to Dr. Elihu Thomson in 1909; subsequently to: Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John W. Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, Frank Conrad.

In June 1928 the A.I.E.E. was privileged to give further recognition to Edison's services and achievements. The Constitution provides that Honorary Members may be chosen, upon the unanimous vote of every member of the board of directors, from among those who have rendered acknowledged eminent service to electrical engineering. Prior to June 1928 the very few distinguished persons thus elected all were from foreign countries, but at that time Edison's name headed the list of five outstanding American engineers unanimously endorsed by the directors.

The Genius of Edison

In his biography "Edison As I Know Him," Mr. Ford described Edison as "a genius but not in the sense that his inventions and discoveries have been revealed to him in sudden flashes. If he

Two "wizards" at work—Edison and Steinmetz examining porcelain insulators fractured by artificial lightning

were that, he would not have his present tremendous importance, for the lessons of his life would not have universal application. As it is, his methods can be used by any one; and the fact that they are being used by so many is one of the reasons for our great industrial progress. The man stands as a demonstration of what concentration and intelligence can accomplish."

One of his earlier interests and certainly the one most consistently and earnestly pursued by Edison through and in spite of seemingly insurmountable difficulties, was the development and improvement of the incandescent electric lamp and a parallel system of distribution which would make electric light as readily accessible to the individual consumer as the older established utility systems which provided water and gas service.

Other experimenters had been busy on the problems of both the arc light and the incandescent light, the former of which already had reached a successful commercial stage. Self-exciting generators for both continuous and alternating current had been developed, and as early as 1859 Prof. Moses G. Farmer had conducted successful experiments with incandescent lights comprising a metal filament enclosed in a glass globe from which air had been partially exhausted. It had been predicted by Professor Farmer that the success of the incandescent lamp would hinge upon successful accomplishment of the necessary vacuum. Edison, after contemplating the limitations of the arc light, disregarded contrary current opinion and in the face of ridicule and violent criticism turned his tireless, bold, and imaginative effort toward the development of a commercially successful incandescent electric lamp. Thus it was that on October 21, 1879, Edison achieved his first successful incandescent carbon lamp, the tiny foundation upon which has been built a five billion dollar industry.

The Three Wire System

With the fundamental problem of the incandescent lamp settled, came the demand for improved types of dynamo-electric machines and the development and improvement of commercial distribution systems for electric energy. To meet these demands Edison's tireless work of 1879-80 laid the foundation and unerringly pointed the path which the successful commercial development of electric lighting must follow. It is of interest to note here in passing that Edison was unalterably opposed to the evolution and development of the alternating current system.

The Edison three wire system of distribution, really a multiple-series grouping of lamps supplied by dynamos connected in series with a grounded balance wire between the dynamo connection points and the lamp groups, was as fundamental to the advance of electric lighting as the development of the lamp. As with the lamp itself, the three wire system was invented independently in England, but again it was Edison's driving energy and deep insight that underlay commercial success. The famous Pearl Street station in New York City, the first central electric generating station in the western hemisphere, followed almost immediately upon the completion of a similar station at Holborn Viaduct in London where two 1,000-light Edison generators were placed in service in 1882.

Thomas Alva Edison—

"It is given to few men of any age, nation or calling to become the benefactor of all humanity. That distinction came abundantly to Thomas Alva Edison, whose death in his eighty-fifth year has ended a life of courage and outstanding achievement. His lifelong search for truth, fructifying in more than a thousand inventions, made him the greatest inventor our nation has produced, and revolutionized civilization itself. He multiplied light and dissolved darkness; he added to the whole wealth of nations. He was great not only in his scientific creative instinct and insight, but did more than any other American to place invention on an organized basis of the utilization of raw materials of pure science and discovery. He was a rare genius. He has been a precious asset to the whole world.

"Every American owes a personal debt to him. It is not only debt for great benefactions which he has brought to every American, but also debt for the honor he brought to our country. By his own genius and effort he rose from a newsboy and telegrapher to the position of leadership amongst men. His life has been a constant stimulant to confidence that our institutions hold open the door of opportunity to those who would enter. He possessed a modesty, kindliness, a stanchness of character rare among men.

"His death leaves thousands bereft of a friend, the nation bereft of one of its notable citizens and the world bereft of one of its greatest benefactors. I mourn his passing as a personal friend over a quarter of a century."—

HERBERT HOOVER

Early Inventions

Legitimately hailed as the father of commercially successful electric lighting as it now is known throughout the world, Edison also was the developer and inventor of other ideas, methods, and apparatus entirely too numerous to mention. The record of his inventions at the United States Patent Office shows that since 1868 more than 1,200 patents have been granted to Edison covering an astoundingly wide range of subjects. Prior to his successful development of the incandescent electric lamp in 1879, Edison had invented the phonograph (1877); completed basic inventions in automatic telegraph systems, multiplex telegraph apparatus, and a carbon telephone transmitter which was used by Doctor Bell in the commercial application of his own telephone instrument (1871-77); contributed to the development of the successful working model of a typewriter (1871); contributed inventions fundamental to the ultimate successful development of the stock ticker (1870). His first recorded invention (1868) was his electrochemical vote recorder which he patented with the idea of having it installed in the houses of Congress. As a commercial venture, however, this first recorded patent was a complete failure, the result of which was to cause Edison to devote his subsequent efforts to the development of apparatus for which he could see a reasonably sure market as a reward for the achievement.

The Phonograph

The invention of the basic idea of the phonograph and the development of related materials and apparatus is credited without even the shadow of a competitive claim to the ever-questing inventive brain of Mr. Edison. Imbued with the idea that he could make sound waves record themselves mechanically to be reproduced subsequently at pleasure, Edison is credited with having developed his phonograph within one week after

having first set to work at it. This invention is regarded as illustrating Edison's mastery of many fields. It is evident that his previous work in the development of a commercially successful telephone transmitter provided him with a background of experience and experiments which enabled him to make such startling developments with his phonograph idea.

The "Edison Effect"

In 1883 the phenomena later described as the "Edison Effect" was noted by Edison and discussed at some length by contemporary electrical engineers. In fact, at the first meeting of the Institute held at Philadelphia, Pa., in October 1884, a paper was presented by Dr. Edward J. Houston, "Notes on Phenomena in Incandescent Lamps," and this paper may be found as the first paper in Vol. 1 of the Transactions of the Institute. The discovery of this "Edison Effect" was the fundamental root system upon which was based and from which grew the great radio industry of today, including the thermionic tubes that have been developed for purely industrial purposes. This important fundamental discovery, stumbled upon by the noted inventor, lay dormant for more than 30 years while its discoverer devoted his energy to other and more obvious projects. As was typical with the more or less incidental discoveries made by Edison, he no sooner had evolved the principle than he discarded it when it failed to bear fruit.

Edison's first glimpse of this all-important principle underlying the thermionic tube of today was described in an article in *The Atlantic Monthly* for December 1930:

"While working on his incandescent lamp in 1883 Mr. Edison noticed that when he heated the filament to a certain temperature a blue glow appeared between the legs. Was this electricity flowing through rarefied air? If so, it seemed strange that the current should take this more resistant path in preference to the easier channel provided by the loop filament itself. To satisfy his curiosity the inventor inserted a second element into the bulb—a wire. He connected the wire to the positive terminal of the lamp and found that a weak current did flow from the hot filament, but, curiously, when the connection was changed to the negative terminal, no current flowed.

"Edison noted the experiment in his notebook and turned from this fascinating side issue back to his main job of developing the incandescent lamp. . . .

"It was not until 1905 that this flow of power in a vacuum was harnessed to do useful work."

Thomas A. Edison as Seen by Some Institute Leaders

LEWIS B. STILLWELL—Edison's greatest contribution to mankind was the incandescent lamp and the central station for supplying electricity through feeders and mains to adjacent territory. Next to this achievement, his greatest contribution, perhaps, has been the stimulus of his example. His simplicity of life, his untiring industry, and his infinite patience in overcoming difficulties have been an inspiration to countless workers.

GANO DUNN—If for no other reason, Edison will be immortal as the first man to record and reproduce human speech. His contributions to electrical generation, distribution, and illumination, without including the invention of the phonograph, place his name among the great ones of the earth. In his death I lose an inspiration and a kind personal friend from boyhood, whose youth and vitality of personality blazed to the last as a light to the world.

HARRIS J. RYAN—Mr. Edison was much more than the inventor of the incandescent lamp, the phonograph, and the motion picture. He will rank forever with the greatest practical explorers of the feasibles and permissibles that determine human welfare and happiness on this earth. He did a lion's share of the work that will forever distinguish the transition from the 19th to the 20th century. He was a philosopher who, by his example, taught millions the glory of unremitting toil.

A. E. KENNELLY—We of the electrical engineering fraternity deeply regret the loss of our great American inventor, Thomas A. Edison. As his principal electrical assistant from 1887 to 1894 it was my privilege to work with him daily. His great energy and enthusiasm made those years very happy and memorable to me. As a chief, he was always inspiring, encouraging, and sympathetic, and all of us at the laboratory revered and loved him. We forgot obstacles and even the passage of time, in our work under the direction of his grand personality.

M. I. PUPIN—Edison's greatest contribution to the comforts of mankind undoubtedly is the incandescent electric lighting system. Edison always loved to reminisce about his wonderful experiences in the course of developing the incandescent filament, and no biography will be complete without these reminiscences. This development work, crossed at every step by almost insurmountable difficulties, illustrates better than anything else Edison's genius. He was a great inventor, but he was also a great personality, the unique combination of the two will never be forgotten.

C. E. SKINNER—The name of Thomas A. Edison and the development of the electrical industry are and will be inseparable. His contributions to the electrical art, as well as to many other subjects, have been continuous for more than fifty years. His research has been characterized by tireless energy and a mind which led him to try methods and materials for the attaining of his objectives which perhaps would never be thought of by the average research worker. In his passing the electrical industry loses its greatest pioneer and the world an unique and outstanding figure.

Motion Picture Development

Work done by Edison in 1889-90 and 1891, resulted in his achieving basic inventions in the field of motion picture recording and projecting. This work was followed by additional developments during the ensuing 35 years or more which contributed toward the development of successful motion picture apparatus. It is interesting to note in this connection that although Edison made inventive contributions of the greatest importance in the field of the phonograph and the photographic film for the recording and reproduction of sound waves, and also in the field of motion picture recording and projecting, it is reported authentically that Edison was convinced even up to his last active days that the combination of sight and sound in the form of the modern talking motion picture would prove to be but a passing public fancy and, therefore, not attractive enough to him to cause him to devote serious energy to it.

Edison in Chemistry

Edison had a strong liking for experimental work in the field of chemistry, an interest which periodically had burst into flame during his many years of development efforts, but which always had been pushed into the background to keep the way clear for his other major activities. However, the participation of the United States in the World War and Edison's immediate devotion of effort to government service gave him the opportunity to "putter" with chemicals, something which for several years he had been hoping for privately. Faced with a direct need for carbolic acid, aniline dyes, and other chemicals in this country, normal supplies of which had been interrupted by war conditions, Edison took great pleasure in the fact that "within sixty days after we decided to make carbolic acid we had a plant built and were making it."

As head of the United States Navy Consulting Board (1915) and life head of the United States Naval Recruiting Board (1917) Edison devoted his seemingly tireless energy to the development of vitally important new war materials and equipment. After the war Edison devoted much attention to the project of developing a domestic rubber supply and experimented with synthetic products. As usual, however, this was just one of his many and widely varied activities.

Space limitations prohibit the reproduction here of anything like a complete life story of Mr. Edison's many sided activities. Those interested in the details of the life of this inspired world character are referred to the biographies "Edison As I Know Him" by Henry Ford, "Edison, the Man and His Work," by Geo. F. Bryan, and the biography pre-

pared by William H. Meadowcroft, historian for the Edison Pioneers, and lifelong associate of Mr. Edison.

Turning from Edison the inventor to Edison the man, one finds a simple, direct stable philosophy of living given such a dynamic force by the example of his devotion to his work that its stimulating and inspiring effect will outlive him by generations. Students in the fields of applied science have had in him an ideal by which to guide their ambitions; by his infectious enthusiasm and vitality of personality men of science and industry have been encouraged to redoubled efforts in the face of devastating adversities. By his example he demonstrated the glory of unremitting toil directed toward knowing things and doing things that are of service to humanity. Thus, recognition is due him by Humanity as well as by Industry. The fruits of Edison's vigor, indomitable courage, and simple, effective philosophy of hard work beyond doubt were made available to the world for an unusually extended period through the untiring ministrations of his wife, Mina Miller Edison. Thus also is a debt of gratitude owed to her.

In Memory of Thomas Alva Edison

The physical life of Thomas Alva Edison, world benefactor, ended on Sunday, October 18, 1931. The spiritual benefits of his contributions to humanity continue to live.

His genius, vision, patience, persistence, industry, and widely diversified talent, which brought to fruition many of his conceptions, have contributed greatly to the comfort, convenience, and happiness of mankind; his achievements constitute a great incentive and inspiration to those who follow.

In particular, his invention of the incandescent electric lamp and his conception, more than 50 years ago, of the combination of a central generating station with a suitable distributing system for electric energy firmly establish him as the founder of the electric lighting industry of the world.

He was the outstanding world leader in the group of inventors, scientists and engineers, whose achievements in technology have produced great social and economic benefits including the employment, in useful occupations throughout the civilized world, of tens of thousands of men and women.

He was respected and admired by his associates who cherish their memory of his ability, simplicity, and other personal characteristics.

Mr. Edison was, in 1884, one of the signers of the call for the organization of the American Institute of Electrical Engineers, and he was elected vice-president at the first election of officers; later he was elected an Honorary Member. His achievements caused a group of his associates and friends to establish the Edison Medal, which now is awarded annually by this Institute.

The board of directors of the A.I.E.E. hereby records in its minutes this appreciation of the great debt which the world, and electrical engineers in particular, owe to his memory, and directs that a copy of this minute be sent to his family.—From the minutes of the regular meeting of the board of directors, held at Kansas City, Mo., October 23, 1931.

November 15 Last Date for Suggesting Nominations

Actions specified in the Institute's constitution and by-laws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the Spring of 1932 will be held between November 15 and December 15. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, not later than November 15.

Secret Telegraph Messages.—A new and very successful means for telegraphic and wireless transmission in secret was described recently before the Academy of Sciences by General Gustave Ferrie of the French Institute. The new method makes use of devices in a French inventor's system of sending orthographic texts by means of cylinders moving at variable speeds and synchronized according to a prearranged plan between the sending and receiving stations. Each message bears the reproduction of the signature of the sender. It can be concealed further from any outside station by means of a simultaneous and more powerful text which has no connection with the secret message. General Ferrie stated that this system was expected to prove valuable for military and diplomatic communications.—*Telegraph and Telephone Age.*

Electric Furnaces Improved for Iron and Steel Plants

During the past two decades electric furnaces for melting and refining in the iron and steel industry have shown noteworthy progress. In a paper presented by W. E. Moore, metallurgical engineer of the Pittsburgh (Pa.) Electric Furnace Corporation, before the sixtieth general meeting of the Electrochemical Society held September 2-5, 1931, at Salt Lake City, Utah, it was stated that the electric arc type of furnace has increased sixty-five times in number, five times in maximum size per heat and ten times in maximum daily capacity. Power consumption was said to have been decreased from an approximate average of 700 to about 500 kw-hr. per unit ton output with a corresponding decrease in carbon electrode consumption from an approximate average of 35 to about 11 or 12 lb. per unit ton output. It is stated that by reason of these improvements, as well as by reason of the more rapid type of operation and lower maintenance, refractory, and slag costs, the total conversion cost has been reduced accordingly.

In comparing production figures it is stated that in 1910 ten electric steel furnaces were in operation in the United States producing 52,141 gross tons of electric steel during that year. In 1930 approximately 650 electric furnaces were in operation on iron and steel properties in the United States, giving an average annual output of more than 1,000,000 tons gross, of which approximately one-third was ingot and two-thirds steel and iron castings. It was stated further that approximately one-third of all steel for castings now is melted electrically.

Noble Prize Awarded by A.S.C.E.

Announcement just has been made of the award of the 1931 Alfred Noble Prize to Prof. C. T. Eddy, of the Michigan College of Mining and Technology, Houghton, Mich. This is the first award of this prize, which is accompanied by $500 in cash, and which should be of particular interest to all the younger members of the engineering profession.

The older members of that calling well remember Alfred Noble who, during a professional career of more than 50 years ending in 1914, participated in many public works for which the citizens of the United States still remain his debtors, although his characteristic modesty prevented his name being known in connection with them. His experience was of value in connection with the location and construction of the Panama Canal. He was one of the engineers who built the Pennsylvania (R. R.) Terminal in New York City. The project of bringing water from the Catskill mountains to the City of New York was guided in part by his knowledge and advice. In addition to his technical achievements, Mr. Noble took a great interest in the welfare of his colleagues, especially in the younger men who were just starting out in the engineering profession.

Very soon after his death, the American Society of Civil Engineers, of which he had been president in 1903, appointed a committee to collect funds for a memorial to perpetuate his memory. This finally has taken shape in a fund the income of which is to be used for an annual award of $500 to a younger engineer, who might thereby be encouraged in his chosen work and be led to emulate Alfred Noble, though he had never had the privilege of knowing him.

The prize is awarded upon the recommendation of a committee consisting of representatives from the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers. Award is made for a technical paper of particular merit written by a member of one of these societies, and accepted for publication before the author has reached the age of 30 years. Professor Eddy's paper, on "Arsenic Elimination in the Reverberatory Refining of Native Copper," to be published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers, of which he is a member, was adjudged worthy of the first award. The presentation will take place at a future meeting of the A.I.M.E.; and the prize will be given to Professor Eddy by a representative of the A.S.C.E., trustee of the fund.

New York Power Group to Discuss Protection

The A.I.E.E. New York Section Power Group will hold a meeting devoted to power system protection on the evening of November 24, in Room 1, fifth floor, Engineering Societies Building, 33 West 39th Street, New York, N. Y. Addresses will be delivered by H. D. Braley, assistant engineer, New York Edison Company, and by H. P. Sleeper, engineer, Public Service Electric and Gas Company.

Mr. Braley will emphasize the necessity of planning protection in close conjunction with system design, both present and future; Mr. Sleeper will review pertinent operating experiences of his company with various types of system protection. Conforming to the established practise of the New York Section Groups, this meeting will be called promptly at 7:30 p. m. and will adjourn at 9:30 p. m. Discussion is open to all.

Administrative Engineering. — A new course in engineering leading to the degree of Bachelor of Science in administrative engineering has been included in the curriculum of Cornell University, Ithaca, N. Y., coincident with the academic year 1931-32. It is stated that this course has been instituted in answer to demands from industry for engineers having the training necessary to qualify for administrative responsibilities in engineering and industrial enterprises. The new course requires four years for completion and includes ten subjects of a non-engineering nature.

Leading Educator Dies

S. W. STRATTON

Dr. Samuel Wesley Stratton (A'04-F'24) chairman of the Massachusetts Institute of Technology Corporation and former president of M.I.T., died suddenly at his home October 18, 1931. Doctor Stratton was born July 18, 1862, at Litchfield, Ill., and was graduated from the University of Illinois in 1884 with the degree of bachelor of science in mechanical engineering. Later he received honorary degrees from the University of Illinois, Rensselaer Polytechnic Institute, University of Pittsburgh, Cambridge University (England), Yale University, and Harvard University. During the period of 1885 to 1892 he was instructor in mathematics, assistant professor, and later professor of physics and electrical engineering at the University of Illinois, organizing the department of electrical engineering at that institution. The following nine years he was successively assistant professor, associate professor and professor of physics at the University of Chicago, in 1901 becoming director of the National Bureau of Standards at Washington, D. C. Continuously from that time until 1922 he was director of this bureau, being responsible for its organization and development into a great institution, which not only is devoted to the scientific determination of weights and measurements, but has become a great physical laboratory cooperating with American industry and commerce in the solution of many problems of enormous value. Under Doctor Stratton's direction this bureau grew from a small organization of twenty-four employees in temporary quarters near the Capital to an institution with 900 workers and fourteen permanent buildings. In 1923 he resigned this position to become president of Massachusetts Institute of Technology, Cambridge, Mass., in order that he might adapt the practical and efficient methods of the bureau to what was already a leading technical school. In 1930 he was appointed chairman of the Massachusetts Institute of Technology Corporation executive board, calling Dr. Karl T. Compton, head of the department of physics at Princeton University, to be president. France made him a chevalier of the Legion of Honor in 1909, and an officer in 1928; he had received the Elliott Cresson Medal of the Franklin Institute, and the Welfare Medal of the National Academy of Sciences. He belonged to many clubs and organizations, among which were the American Society of Mechanical Engineers, the American Physical Society, the American Philosophical Society, the National Academy of Sciences, and the American Association for the Advancement of Science. He was also a member of the interdepartmental board of the Council of National Defense, and the National Advisory Committee for Aeronautics; three years ago he accepted the invitation of Secretary Wilbur to serve on the navy board named to study safety devices for submarines.

Winter Convention Plans are Announced

With the technical program for the 1932 winter convention of the Institute already essentially completed, activities and preparations for the coming event now are in full swing with the appointment by President Skinner of the general convention committee. Winter convention activities are scheduled for Jan. 25-29, 1932, with convention headquarters at the Engineering Societies Building, 33 West 39th Street, New York, N. Y.

As members of the general convention committee, Doctor Skinner has appointed the following: *chairman*, E. B. Meyer (F'27) chairman publication committee; O. H. Caldwell (M'22) chairman New York Section; H. P. Charlesworth (F'28) vice-president; Harold C. Dean (F'30) secretary New York Section; W. H. Harrison (F'31) chairman meetings and papers committee; C. R. Jones (F'31) secretary, New York City District; G. L. Knight (F'17) A.I.E.E. representative on Board of Trustees, United Engg. Trustees, Inc.; C. E. Stephens (M'22) chairman finance committee; R. H. Tapscott (F'29) chairman headquarters committee.

In planning the technical program special efforts are being made to cover the art completely during the year. Hence, on the winter convention program there surely will be several sessions on

subjects which have not been presented at this annual affair during the past few years. Indications point toward the presentation of a very large number of papers, some of which will be presented from the manuscript without publication, and without distribution of an advance copy. Three sessions tentatively scheduled accommodate symposiums: (1) distribution circuit lightning protection, (2) system stability, (3) time and time services. The symposium on system stability promises to be of wide general interest. It is sponsored by the joint subcommittee on interconnections which is comprised of members of the committees on power generation, power transmission and distribution, and protective devices. Other subjects tentatively under consideration for sessions are: instruments and measurements, research and general circuit theory, protective devices, electrical machinery, electric welding, communication, electrochemistry and electrometallurgy, transportation, and several selected subjects.

These plans should leave nothing to be desired from a standpoint of technical interests. Plans for the social features, entertainment and inspection trips will not be left undone and these will be announced at a later date.

Letters to the Editor

Corona and Line Surges

To the Editor:

Dr. H. H. Skilling's article "Corona and Line Surges," which appeared in the October 1931 issue of ELECTRICAL ENGINEERING, prompts me to submit a comparison between the following four different formulas for the attenuation of traveling waves:

1. Simple exponential attenuation, which is exact for the ideal transmission line in which the line "constants" R, L, G, C are true constants.
2. The Foust and Menger empirical formula, which appeared in W. W. Lewis's 1928 A.I.E.E. paper "Surge Voltage Investigation of Transmission Lines."
3. The Skilling formula, described in his article.
4. A formula based on the assumption that the corona loss for traveling waves follows the quadratic law, the derivation of which is given as an appendix to these comments.

Referring to Fig. 1, in which these four formulas have been plotted so as to pass through a common point at 50 per cent of the initial voltage of the surge, it may be seen that there are three principal regions involved:

Region I—from the initial voltage of $E = 2{,}000$ kv. to the 50 per cent voltage point of 1,000 kv.

Region II—from $e = 1{,}000$ kv. to the critical corona voltage $e_0 = 500$ kv.

Region III—below the critical corona voltage $e_0 = 500$ kv.

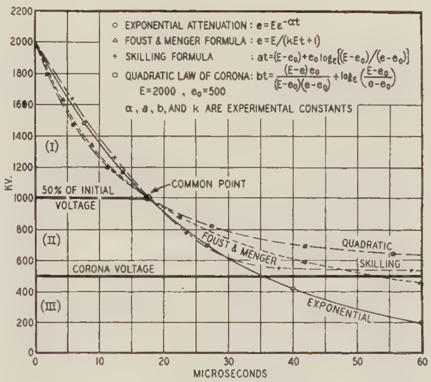


Fig. 1. Comparison of formulas for attenuation of traveling waves

In region I, the Foust and Menger formula agrees almost perfectly with the quadratic formula, and Skilling's formula agrees equally well with the exponential law. The difference between these two pairs is not great, and of little practical importance. In this region of greatest interest all four formulas are of practically equal accuracy, and therefore the formula will be used which is the most convenient. The Foust and Menger formula is the most simple for estimating the attenuation, but the exponential formula is easier to operate mathematically.

In region II the Foust and Menger formula parts company with the quadratic formula, but the Skilling formula and exponential law continue to agree until the critical corona voltage is neared, when the Skilling formula abruptly flattens out while the exponential crosses to region III.

Both the Skilling and the quadratic formulas are asymptotic to the critical corona voltage, and therefore do not appear in region III. The Foust and Menger and the exponential formulas enter region II, but at widely different points and diverge considerably.

While the exponential, Skilling, and quadratic formulas, appear on the surface to have been derived by a rational process, it should be noticed that all three of them are based upon the assumption that the current and voltage waves are exact replicas of each other; in other words, the distortion is ignored. Moreover, the experimental constants α, a, b have to be determined from tests on the transmission line in question and under the actual conditions that are to prevail. Thus in this respect they are no better off than the Foust and Menger formula. The very abrupt flattening of the Skilling formula as the critical corona voltage is approached is not always evidenced by experimental data.

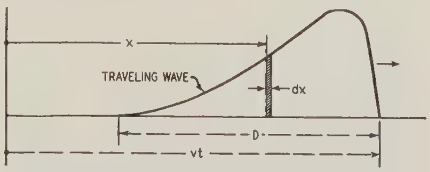


Fig. 2. A typical traveling wave f4

MATHEMATICAL EXAMPLE

Consider a traveling wave $e = f(x - vt)$ of length D, (Fig. 2) and its companion current wave i, and suppose that these two waves are related by the surge impedance:

$$e = Z\,i = \sqrt{\frac{L}{C}}\,i \tag{1}$$

At time t the toe of the wave is at $x = vt$ from the origin, and the total stored energy of the wave is

$$W = \frac{C}{2}\int_{(vt-D)}^{vt} e^2\,dx + \frac{L}{2}\int_{(vt-D)}^{vt} i^2\,ds$$

$$= C\int_{(vt-D)}^{vt} f^2(x - vt)\,dx \tag{2}$$

The rate at which the energy content is changing with respect to t is

$$\frac{dW}{dt} = C\int_{(vt-D)}^{vt} \frac{\partial}{\partial t} f^2(x - vt)\,.\,dx$$

$$+ C\,v\,f^2(vt - vt) - C\,v\,f^2(vt - D - vt)$$

$$= C\int_{(vt-D)}^{vt} \frac{\partial}{\partial t} f^2(x - vt)\,.\,dx$$

$$= C\int_{(vt-D)}^{vt} \frac{\partial e^2}{\partial t}\,dx \tag{3}$$

because $f(0) = 0$ and $f(-D) = 0$

Now if the rate of energy dissipation due to the line losses is a function of the voltage $\phi(e)$, then the total rate of energy loss for the entire wave is

$$\int_{(vt-D)}^{vt} \phi(e)\,.\,dx \tag{4}$$

Equating (3) and (4) and discarding the integrals

$$C\,\frac{\partial e^2}{\partial t} = -\phi(e) \tag{5}$$

subject to the initial conditions

$$e = E(x) \text{ at } t = 0 \tag{6}$$

The solution of (5) thus defines the wave at any instant t. By way of illustration, three special cases will be considered.

CASE I—Ideal Transmission Line.—Such a line is characterized by four line constants R, L, C, G and if eq. 1 holds, the rate of energy loss is

$$\phi(e) = R\,i + G\,e^2 = R\,\frac{C}{L}\,e^2 + G\,e^2$$

$$= \left(\frac{RC + LG}{L}\right)e^2 \tag{7}$$

Substituting (7) in (5) and using (6) this results in

$$e = E\,\epsilon^{-\alpha t} \text{ where } \alpha = \frac{1}{2}\left(\frac{R}{L} + \frac{G}{C}\right) \tag{9}$$

CASE II—The Skilling Formula.—If the loss is assumed to vary as the excess voltage above the critical corona voltage e_0, then

$$\phi(e) = -k(e - e_0) \tag{10}$$

and (5) and (6) give

$$\frac{k}{2C}\,t = a\,t = (E - e) + e_0\log\left(\frac{E - e_0}{e - e_0}\right) \tag{11}$$

CASE III—The Quadratic Formula.—If the loss is assumed to vary as the square of the excess voltage above the critical corona voltage, then

$$\phi(e) = -K(e - e_0)^2 \tag{12}$$

Then by (5) and (6)

$$\frac{Kt}{2C} = \frac{(E - e)\,e_0}{(E - e_0)\,(e - e_0)} + \log\frac{(E - e_0)}{(E - e_0)} \tag{13}$$

I have in the past devoted a considerable part of my time to the study of traveling waves, and feel that the attenuation of surges is the most important thing left to be found out about traveling waves. I think that you will serve the industry by keeping the subject alive by continuing to print articles like Doctor Skilling's, and inviting discussion.

Yours very truly,
L. V. BEWLEY (A'27)
(General Transformer Engg. Dept., General Electric Co., Pittsfield, Mass.)

A Note on Symmetrical Components

To the Editor:

I am submitting herewith a short discussion on symmetrical components which is intended to be an addition to Dr. A. E. Kennelly's article "Computation of the Unbalance Factor of a Three-Phase Triangle When Lengths of Three Sides are Given" which appeared in the JOURNAL of the A.I.E.E., March 1927, p. 240.

In his article Doctor Kennelly develops formulas for computing the magnitude of the direct and reverse sequence components, when given the lengths of the three sides of the voltage triangle. In this discussion I develop a simple formula for the angle between the direct and reverse sequence components, the expression being in terms of the lengths of the sides of the voltage triangle.

In his article Doctor Kennelly gave (the mathematical equivalent of) the following expressions for computing the forward (positive phase or direct sequence) and backward (negative phase or reverse sequence) components of a dissymetric three-phase vector triangle:

$$d^2 = \frac{\dfrac{a^2 + b^2 + c^2}{3} + S^2}{2}$$

and

$$r^2 = \frac{\dfrac{a^2 + b^2 + c^2}{3} - S^2}{2}$$

where a, b, and c are the lengths of the vectors forming the triangle and S (A_S in Doctor Kennelly's article) is the side of an equilateral triangle having the same area as triangle $a\,b\,c$; d and r (e in Doctor Kennelly's article) are, respectively, the magnitudes of the direct and reverse sequence components.

It is the object of this note to obtain an additional expression for the angle between d and r in terms of a^2, b^2, and c^2, terms used in Doctor Kennelly's expressions.

Let the vector representation of a, b, and c be

$$a = d_a + r_a = d\,j\,0^0 + r\,j\,\theta_a \tag{1}$$

$$b = d_b + r_b = d\,j\,240^0 + r\,j\,(120^0 + \theta_a) \tag{2}$$

$$c = d_c + r_c = d\,j\,120^0 + r\,j\,(240^0 + \theta_a). \tag{3}$$

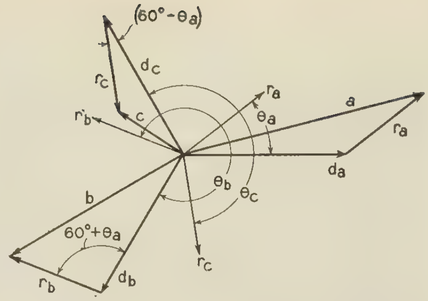
This is quite evident from the accompanying illustration.

By the law of cosines

$$b^2 = d^2 + r^2 - 2\,d\,r\cos(60^0 + \theta_a)$$

and

$$c^2 = d^2 + r^2 - 2\,d\,r\cos(60^0 - \theta_a)$$



Vector relations in an unbalanced three-phase system with direct and reverse sequence components

so that

$$\cos(60^0 + \theta_a) = \frac{d^2 + r^2 - b^2}{2\,d\,r} = \frac{\cos\theta_a}{2} - \frac{\sqrt{3}\sin\theta_a}{2} \tag{4}$$

$$\cos(60^0 - \theta_a) = \frac{d^2 + r^2 - c^2}{2\,d\,r} = \frac{\cos\theta_a}{2} + \frac{\sqrt{3}\sin\theta_a}{2} \tag{5}$$

Subtracting eq. 4 from eq. 5

$$\frac{b^2 - c^2}{2\sqrt{3}\,d\,r} = \sin\theta_a \tag{6}$$

Adding eq. 4 and eq. 5

$$\frac{2\,d^2 + 2\,r^2 - b^2 - c^2}{2\,d\,r} = \cos\theta_a \tag{7}$$

But by making use of Doctor Kennelly's expressions for d and r in terms of a, b, and c, eq. 7 can be changed to

$$\frac{2\,a^2 - b^2 - c^2}{6\,d\,r} = \cos\theta_a \tag{8}$$

Eq. 6 must be divided by eq. 8 to obtain the final expression

$$\tan\theta_a = \frac{\sqrt{3}\,(b^2 - c^2)}{2\,a^2 - b^2 - c^2}$$

or

$$\theta_a = \arctan\frac{\sqrt{3}\,(b^2 - c^2)}{2\,a^2 - b^2 - c^2} \tag{9}$$

If use is made of Doctor Kennelly's expressions for d and r, the extra labor required to obtain θ_a will be small since a^2, b^2, and c^2 occur in both expressions.

Assuming the same values which Doctor Kennelly used in his example, let

a = 1,100 volts
b = 1,000 volts
c = 900 volts whence
d = 996.61 volts and
r = 115.91 volts

Using the final eq. 9

$$\theta_a = \arctan\frac{+19\sqrt{3}}{+61} = +28^0\,20'$$

It is interesting to note that by a cyclical interchange of the terms in the expression for θ_a, expressions for θ_b and θ_c can be obtained as follows:

$$\theta_b = \arctan\frac{\sqrt{3}\,(c^2 - a^2)}{2\,b^2 - c^2 - a^2}$$

$$\theta_c = \arctan\frac{\sqrt{3}\,(a^2 - b^2)}{2\,c^2 - a^2 - b^2}$$

Substituting in these expressions for θ_b and θ_c the values for a = 1,100, b = 1,000, and c = 900 volts, θ_b and θ_c can be obtained.

Thus

$$\theta_b = \arctan\frac{-\sqrt{3}\,(40)}{-2} = +268^0\,20' = +240^0 + \theta_a$$

and

$$\theta_c = \arctan\frac{+\sqrt{3}\,(21)}{-59} = +148^0\,20' = +120^0 + \theta_a$$

Hence for a given voltage triangle of arbitrarily designated sides a, b, and c, θ_a will be the smallest angle if a is made to represent the longest side of the given voltage triangle.

Very truly yours,
E. DE LA GARZA,
(Senior Student, 1931, Rice Institute, Houston, Texas)

Editor's Note: In commenting upon this discussion Doctor Kennelly stated that, "Mr. de la Garza's note supplies an important element not covered by my 1927 article; namely, the computed phase relation between the two symmetrical-component machines, *i. e.*, the angle at which each should be clamped on the same rotor shaft in such a way that the two symmetrical systems, electrically connected in opposite directions, would produce identically the same dissymmetrical voltages as the actual dissymmetrical machine provides."

Has Man Benefited by Engineering Progress?

To the Editor:

I assume the invitation to comment on the articles so far published in the symposium "Has Man Benefited By Engineering Progress?" (ELECTRICAL ENGINEERING, Aug. 1931, *et. seq.*) applies also to the general subject and its implications, which constitute a challenge to all of us.

The belief that engineering progress does benefit man has been widely held, otherwise there would be few engineers. It is significant that the question of "benefit" becomes of particular interest during a depression, a phenomenon the recurrence of which recently was considered most improbable. However, depressions or their equivalent occurred long before engineering attained its present stature, so it is evident that engineering is only one of the many factors in the present situation.

The most important factor and the least studied is man himself. The general lack of knowledge regarding the basic human impulses and their significance is most unfortunate. One reason for this is the unpalatability of some of the available facts.

Difficulties in the way of dealing frankly with human impulses are analogous to those encountered by the early scientists in their endeavor to substitute natural law for the popular "supernatural whim" as an explanation of physical phenomena. Modern scientists and engineers do not encounter such serious opposition, but they too are obliged to revise frequently their pet theories to fit the facts, a somewhat painful process which should aid them in dealing with the human factor.

I contend we will never reach a satisfactory basis for human relations until the available knowledge of human beings is more widely diffused. If we are unable to deal adequately with the most important factor, we should not complain when the partial solutions otherwise obtained prove ineffective.

Sincerely yours,
C. T. WELLER (A'20-M'21)
(Electrical Engineer, General Engineering Laboratory, General Electric Company, Schenectady, New York)

Col. R. E. B. Crompton, now in his eighty-seventh year and distinguished for his pioneer work in the British electrical engineering industry, was internationally honored in London by a gathering of scientists presided over by his partner, Frank Parkinson, who described Colonel Crompton as the "grand old man of the British electrical industry." He was eulogized further by Prof. Luigi Lombardi of Italy, and by a toast of the entire electrical industry proposed by the principal American guest, Dr. A. E. Kennelly, of Harvard University, past-president of the Institute.

Personal

Dr. Michael I. Pupin Awarded John Fritz Medal

M. I. PUPIN

MICHAEL IDVORSKY PUPIN (A'90, F'15, HM'28) past-president of the Institute and professor emeritus of electrical engineering at Columbia University, N. Y., has been selected as the recipient of the 1931 John Fritz Gold Medal. The award was made to him as a leading scientist, engineer, and author, and as inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils. The John Fritz Medal is the highest honor given by engineers of the United States and was awarded to Doctor Pupin unanimously by the joint board of sixteen prominent engineers representing the four Founder Societies and their aggregate membership of more than 60,000.

Doctor Pupin is professor of electromechanics and director of the Phoenix Research Laboratory at Columbia University, and of course is widely known for his contributions to long distance communication and for his advanced work in electrical resonance, the passage of electricity through gases, and many other scientific subjects. To many thousands of persons the fascinating story of his life has been made known through his inimitable autobiography "From Immigrant to Inventor" and his other writings. He was born a Serb in a Hungarian province Oct. 4, 1858. He came to America as a youngster and after courageous struggles won an opportunity for an education; was graduated from Columbia University in 1883. Thereafter he studied further and received a degree of doctor of philosophy from the University of Berlin; subsequently was granted his doctor of science degree by both Columbia and Princeton universities, and his doctor of laws degree by Johns Hopkins and New York universities, Muhlenberg College, and other educational institutions. He is a past-chairman of The Engineering Foundation and his affiliations include the American Association for the Advancement of Science, National Academy of Sciences, New York Academy of Science, American Philosophical Society, American Physical Society, and other learned organizations. During the World War he served on the National Advisory Committee for Aeronautics, and many other bodies doing scientific research for the government. Doctor Pupin's other honors include the Edison Medal of the A.I.E.E., and the Carson Gold Medal of the Franklin Institute. Among earlier recipients of the John Fritz Medal are Admiral David Watson Taylor (retired) of the U. S. Navy, President Herbert Hoover, Ralph Modjeski, John J. Carty, John F. Stevens, Ambrose Swasey, Guglielmo Marconi, Sir Robert Hadfield, Charles P. E. Schneider, and Elihu Thomson.

ANDRÉ E. BLONDEL (HM'12) professor at l'Ecole Nationale des Ponts et Chaussées, Paris, France, received certificate of Honorary Membership in the Illuminating Engineering Society at a special Silver Anniversary session held in Pittsburgh, Pa., October 14, 1931. The certificate was presented "in recognition of his contribution to science and the art of illumination as educator, scientist, engineer and inventor in the scientific design of light-distribution glassware, originator of great improvements in arc lights and of methods and apparatus for photometrical measurements; author of many memoirs on the theory and practise of illumination and of the units of measurement applicable thereto. A man whose courage has enabled him to overcome most formidable physical handicaps and whose knowledge and sympathy are of international scope." The certificate itself a masterpiece of artistic workmanship, together with its purport, made an especially suitable award for Mr. Blondel's achievements in the fields of professional art and science.

DWIGHT P. ROBINSON (F'13) has resigned from the presidency of United Engineers & Constructors, Inc., Philadelphia, Pa., having completed his work of coordination of the activities of the United Gas Improvement Contracting Company, Day & Zimmermann Engineering & Construction Company, the Public Service Production Company, and Dwight P. Robinson & Company, Inc. He is succeeded by E. M. Chance, vice-president. For over forty years identified with organizing and administrative work on outstanding construction enterprises, Mr. Robinson is a well-known figure in today's engineering field. His achievements with the Stone & Webster organization as well as the wealth of experience which he has acquired in the operation of its subsidiaries as early as 1913 placed him in the front ranks of the profession. His field of application has never been a restricted one; in addition to his activities in electrical construction, he was, from 1913 to 1917 consulting chemist and engineer for anthracite and bituminous coal mining companies in Pennsylvania and West Virginia.

ELIHU THOMSON (F'13-HM'28) charter member and past-president of the Institute, on October 14 at a special session of the Illuminating Engineering Society's Silver Anniversary convention, Pittsburgh, Pa., had honorary membership in the I.E.S. bestowed upon him, "in recognition of his contribution to science and the art of illumination as an educator, scientist, engineer and inventor; distinguished as a pioneer in electric lighting and in the development of electric arts; in recent years renowned through his contributions to the technology of quartz and its application to illumination problems, particularly the preparation of specula of hitherto unattained dimensions; the recipient of many honors at home and abroad and beloved by all who know him."

PRESIDENT SKINNER (F'12) recently was the guest speaker at the Silver Anniversary convention of the Illuminating Engineering Society, held in Pittsburgh, Pa., October 13-16, 1931. His address delivered at the special Silver Anniversary session which took place Wednesday evening briefly and interestingly sketched the "progress of illumination" from the time when he first saw an electric light, at a traveling circus, through the period of transformation twenty-five years had accomplished "to the point where it is equal in its efficiency to daylight." He also spoke of the use of illumination "as an artistic expression to such an extent that buildings, parks, and fountains become things of beauty after the night has fallen."

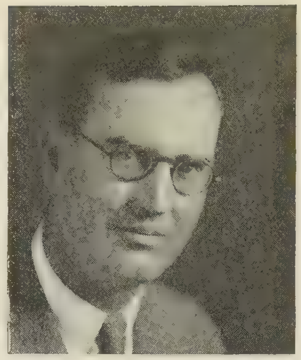
G. H. Harries (F'22) major-general U. S. A. (retired) formerly vice-president for H. M. Byllesby & Company, Chicago, Ill., and for nearly forty years representative of investors, operators, estimators and consumers of electric energy throughout the country, now has retired from the active engineering field. General Harries at various consecutive periods, has been treasurer of the National Electric Light Association, and president of the Association of Edison Illuminating Companies, the American Electric Railway Association and the Illumination Engineering Association. Upon retirement he has chosen Los Angeles, Calif. as a place of residence.

Lyman Winn (A'30) who has been doing sales engineering work with the Shelby Electric Company at Memhpis, Tenn., recently joined the engineering force of the Standard Electric Company there in like capacity. Mr. Winn was a member of the committee which wrote the constitution and by-laws of the Institute's Memphis section; he also has contributed to technical literature through the columns of *Mill & Factory*, an Illinois publication.

H. H. Anderson (M'27) who was engineer of special investigations for the Shell Oil Company, San Francisco, Calif., now is assistant to the president of the Shell Union Oil Corporation, New York, N. Y. Mr. Anderson was at one time a member of the executive committee of the division of development and production engineering of the American Petroleum Institute, and has published a number of technical articles in that field.

A. E. Kennelly, (F'13) professor emeritus of electrical engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass., has gone to Japan. At the invitation of the Institution of Electrical Engineers of Japan, he will deliver a group of lectures during November before five Japanese universities as the first visiting American professor under the Iwadare Foundation.

E. R. Davis (A'09) who has been manager of construction for the Southern California Edison Company, Ltd., Los Angeles, now has assumed additional duties as its manager of construction and engineering with executive supervision of both of these departments. Coincident with his new appointment his company has organized an engineering executive committee with Mr. Davis as a member.



T. H. MORGAN

T. H. Morgan (A'23) who has been assistant professor of electrical engineering, secretary of the electrical engineering faculty and assistant to the executive head of the department, at Stanford University, now has been called East to occupy the position vacated by Prof. H. B. Smith, head of the department of electrical engineering at Worcester Polytechnic Institute, Worcester, Mass. Professor Morgan, who is a native of Fredericton, New Brunswick, Can., received his early technical training at the University of British Columbia (1913-16), Stanford University (1917-1919-1920) followed by postgraduate studies in electrical engineering there (1928-1929). Before becoming assistant professor at Stanford University he was for four years an instructor. He has had also extensive practical experience in the superintendency of the Foundation Company, Victoria, B. C., as test engineer of the Inspiration Consolidated Copper Company, Arizona, and as engineer of the Great Western Power Company, San Francisco, Calif. In 1927 he was secretary of the electrical engineering faculty of Stanford University, counselor of the Stanford A.I.E.E. Branch, chairman of the committee on Student activities as well as of the committee on prizes and awards of the 8th District in 1929. Prof. Morgan is a member of the Society for the Promotion of Engineering Education, and a liberal contributor to technical literature.

C. W. Rice (F'12) secretary of the American Society of Mechanical Engineers, New York, N. Y., has been honored by Verein Deutscher Ingenieure at its 75th anniversary meeting in Cologne, when he was the recipient of its medal "in grateful appreciation of services to technical-scientific achievement, particularly in promoting mutual international interests."

A. V. Guillou (M'27) has resigned from the position as assistant chief engineer of the California Railroad Commission after four years of service in that position. He will now function as chief engineer for the newly formed Public Service Commission of Wisconsin. Mr. Guillou is well known in his work with the various power companies of California.

M. K. McGrath (M'27) vice-president of the International Telephone & Telegraph Corporation whose change of residence from London, England, to New York, N. Y. was posted in the July 1931 issue of Electrical Engineering, now is located with the Postal Telegraph-Cable Company in Chicago, Ill.

A. G. Ennis (A'31) who was engineering assistant in the mechanical department of the Philadelphia & Reading Coal & Iron Company, now is identified with the George Washington University, Washington, D. C., in the capacity of instructor in the electrical engineering department.

W. B. Massenburg (A'31) of Warrenton, N. C., recently has made new connections with the Westinghouse Electric & Manufacturing Company, at Philadelphia, Pa. He was at one time associated with the home office at East Pittsburgh, Pa., in the sales engineering department.

E. N. Willis (M'28) executive secretary of the University Club at Dallas, Texas, and at one time branch manager of the New Orleans branch of the Auto Men's Association, has opened his own business offices in the Electrified Ozone Water Company, Brownsville, Texas.

Winthrop Allen (A'30) who has been working with E. I. du Pont de Nemours Company, Wilmington, Del. as assistant electrical engineer now has associated himself with the Prudential Insurance Company, Newark, N. J., as electrical engineer of home office buildings.

C. L. Edgar (F'12) president and general manager of the Edison Electric Illuminating Company of Boston, recently was chosen chairman of the executive committee of the Society for Electrical Development. He already has served this society as president.

A. J. Grant (A'26) of the meter engineering department, Westinghouse Electric & Manufacturing Company, Newark, N. J., has removed to Ottawa, Ontario, Canada, where he will assume new duties in the physics department of the National Research Council.

C. E. Allen (F'14) previously southwest district manager for the Westinghouse Electric & Manufacturing Company, St. Louis, Mo., and subsequently at the East Pittsburgh works, now is located at Mansfield, Ohio, works of this company.

A. W. Manby (A'22) who was chief operator at the Queenston generating station of the Hydro-Electric Power Commission of Ontario, Niagara Falls, N. Y., has been transferred to its new Chats Falls plant, Fitzroy Harbour, Ontario.

William Shuler (M'24) who has been serving the Columbia Engineering & Management Corporation, Cincinnati, Ohio, as its electrical engineer now has made new connections with the Dayton Power & Light Company, Dayton, Ohio.

P. A. deMars (M'31) who was previously professor of electrical engineering at Tufts College as well as consulting engineer, Boston, Mass., recently was chosen technical director of the Shepard Broadcasting Service, Inc., in that city.

O. W. Walter (M'29) research engineer, Hall Electric Heating Company, Inc., Philadelphia, Pa., now is assistant professor in electrical engineering at The College of the City of New York and is residing at Hastings-on-Hudson.

W. Viessman (M'29) mechanical and electrical engineer, Bureau of Mechanical and Electrical Service, City of Baltimore, Md. now is engaged in an industrial consultant service of his own as mechanical-electrical engineer in that city.

R. L. Cotton (A'30) junior engineer with the New York Edison Company, New York, N. Y., has made new affiliations with the American Radio News Corporation, New York, N. Y., which he will serve as station engineer.

C. E. Crofoot (M'28) who previously was in the technical high school department of the Utica Free Academy, Utica, New York, now is in the technical school department of the Mount Pleasant High School, Schenectady, N. Y.

W. W. Macalpine (A'30) who has been radio engineer for the International Communication Laboratories, Mount Vernon, N. Y., has been chosen director of research, Communication Patents, Incorporated, at Ampere, N. J.

M. B. Wyman (A'30) who for some time was central station engineer of the general engineering department, Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa., now has removed to this company's office at St. Louis, Mo.

A. J. Bronold (A'29) sales assistant of the Westinghouse Electric & Manufacturing Company's specialist group, Pittsburgh, Pa., has made recent affiliations with the Westinghouse Lamp Company, at Columbus, Ohio.

A. B. Chapman (A'29) who for some time has been serving the RCA Victor Company, Incorporated, as service engineer at Oklahoma City, Okla., now has taken up new work for that company at Dallas, Texas.

W. M. Young (A'24) of the department of electrical engineering, University of Iowa, Iowa City, Ia., has joined the engineering research department of the Taylor Instrument Company, Rochester, N. Y.

H. A. Barre (A'11) chief engineer of the Southern California Edison Company, Ltd., Los Angeles, serves with E. R. Davis on the recently created engineering executive committee of that organization.

H. B. Briggs, Jr. (A'30) who has been located in New York, N. Y. as electrical engineer for Theodore E. Ferris, has accepted position with the Bath Iron Works Corporation, at Bath, Me.

E. A. Preisel (A'30) who has been switchboard draftsman for the Westinghouse Elec. & Mfg. Company, Buffalo, N. Y., now has joined that company's forces at Newark, New Jersey.

H. Romander (A'28) engineer, Federal Telegraph Company, Palo Alto, Calif., has removed to Newark, N. J., where he will serve the Federal company in the capacity of radio engineer.

A. D. Pettee (A'20) consulting engineer for the General Cable Corporation at Perth Amboy, N. J., now is consulting engineer for accessories at the Chicago office of the corporation.

H. E. Gumbart (A'25) who was serving as division sales engineer for the Brown Company, Chicago, Ill., now has been transferred to the company's office at Portland, Maine.

G. K. Morrison (A'23) electrical engineer, Federal Telegraph Company, Palo Alto, Calif., has removed to Newark, N. J. where he is still serving this company.

S. L. Poohar (A'31) field service engineer for the RCA Photophone, Inc., Atlanta, Ga., has been transferred to that company's offices at Irwin, Pa.

J. S. Mahan (F'27) field engineer of Steel & Tubes, Inc., Chicago, Ill., now is serving Electrotrim, Incorporated, of that city, in like capacity.

Hugh Skilling (A'28) of San Diego, Calif., has removed to Stanford University, Calif., for university work there.

Obituary

Garnett Holstein Finks (A'16) engineer of the power sales division of the Alabama Power Company, Birmingham, Ala., with which he had been associated since 1922, died at his home September 18, 1931, of pneumonia. He was born at Bertha, Va., July 20, 1891, was a student in electrical engineering at the Virginia Polytechnic Institute, and immediately thereafter engaged in machine shop practise and general construction with the Mathieson Alkali Works. During the period 1912-1913 he was in the electrical departments of the Norfolk and Western Railway, where he was called upon to study a multiplicity of electrical application. In the subsequent position of chief electrician for the Gilliam Coal and Coke Company, the Arlington Coal and Coke Company, the Shawnee Coal and Coke Company and the Glen Alum Coal Company (in advisory capacity) he was given charge of all of their electrical and mechanical work involving maintenance and construction of power plants and machine shops. This was his position until he joined the U. S. government forces at the Hog Island Shipyard, thence to be transferred to the government aviation department at League Island. Shortly after the close of the war, Mr. Finks became connected with the Mill & Mine Engineers, at Birmingham, Ala., which led in 1922 to his being chosen power engineer of the sales department of the Alabama Power Company, his last position.

Harold Calvert (A'17) consulting engineer with the firm Calvert & Barnes, Philadelphia, Pa., died June 27, 1931, in Philadelphia, the city of his birth. He was born April 7, 1875. He attended the University of Pennsylvania, graduating in 1893 with the degree of B. S. in E. E.; in 1897 he obtained his E. E. degree from this same university. His first work in the practical field of electricity was on storage battery installations and switchboard design, in the drafting department of the Electric Storage Battery Company of Philadelphia. In 1900 he became draftsman for the firm of McIntosh & Seymour, Auburn, N. J., on engine design, and two years later he joined the Philadelphia Electric Company as draftsman on station design; later becoming inspector on station construction, and still later made estimating engineer for the writing of wiring specifications for light and power. From this work Mr. Calvert was promoted again to the charge of design and inspection of customers' installations, later forming his own company. In this practise Mr. Calvert but emphasized his already established reputation as a worthy consultant.

Gifford LeClear (A'97-M'28) prominent member of the engineering firm of Densmore, LeClear & Robbins, Boston, Mass., died at his home in Waban, Mass., September 24, 1931, at the age of 57. He was a native of Rutherford, N. J. He won his A. B. degree from Harvard University in 1895 and his A. M. in 1896. For three years he was assistant professor of physics at Harvard, later obtaining practical experience with the West End Street Railway. In 1898 his own company was formed, first as Densmore & LeClear and later as Densmore, LeClear & Robbins, architects and engineers. Mr. LeClear took charge of the electrical work. As an engineer he enjoyed a national reputation; his design and engineering skill is associated with the erection of the Harvard Medical School group of buildings in Boston, and for many years his genius was called upon for similar institutional work in this locality. He also served on a committee which laid out a comprehensive traffic signal system for the city of Boston. Many of this city's latest and most modern buildings are products of his ingenuity. He was one of the leading spirits of the city.

Joseph Bijur (A'94-F'13) president of the Bijur Lubricating Corporation, New York City, and Life Member of the Institute, died suddenly October 19, 1931.

Oliver Jackson Bushnell (M'19) superintendent of the meter department of the Commonwealth Edison Company, Chicago, Ill., died recently at his home in Hinsdale, Ill. He was born at Rockton, Ill., September 13, 1871. Shortly after being graduated from a classical course at Beloit College, he entered the employ of the Chicago Edison Company, and in 1895 was appointed superintendent of the meter department. As a member and later chairman of the meter committee of the Association of Edison Illuminating Companies he assisted in the preparation of the meter code; and as chairman of the N.E.L.A. meter committee, he instituted and supervised the preparation and publication of the Electrical Meterman's Handbook. In 1919 he joined the Commonwealth Edison Company to take direct charge of the customers' meter engineering including the 80,000 demand meters of the company. Only recently he was appointed to the committee of advisors on measuring instruments of the United States national committee of the International Electrotechnical Commission.

Cyril Thomas Wall (A'31) of St. Paul, Minn., died August 22, 1931. He was born at Evansville, Ind., March 30, 1906, and was student equipment engineer for the Northwestern Bell Telephone Co., chief engineer's department, Minneapolis, Minn. His degree of Bachelor of E. E. was conferred upon him by the University of Minnesota, June 1930.

Local Meetings

District 6 Executive Committee Meets at Omaha

On Sept. 28, 1931, the executive committee for the Institute's North Central District met in the Telephone Building at Omaha, Neb. Present were P. H. Patton (Omaha) District vice-president; N. R. Love and Dr. R. E. Nyswander of the Denver Section; H. F. Rice of Grand Forks, N. D.; A. L. Turner (Omaha) and Clarence Talsma (Omaha) of the Nebraska Section; and C. E. Skinner, president of the Institute.

Following Doctor Skinner's informal talk about Institute policies and problems, the committee turned to its routine business electing Vice-President Patton as District delegate on the national nominating committee, with A. L. Turner as an alternate. To serve on the District prize awards committee, H. S. Sands of Denver was appointed chairman of a committee to consist of himself, A. L. Jones of Denver, and C. D. Robison of Omaha.

Ways and means were discussed of stimulating greater participation in Institute affairs by both Members and Enrolled Students. It is contemplated that efforts will be made to stimulate the preparation and presentation of more papers by both Section members and students, so that there may be a larger number of papers available for prize competition. It was urged also that qualified persons contemplating trips through the District should be encouraged to arrange stop-overs in order to permit them to address the Student Branches particularly those farther removed from the headquarters of the District's two sections. In this connection also was mentioned the success attending the Denver Section's practise of holding its annual business meeting on the campus of the University of Colorado (Boulder) in cooperation with the students "engineers' day" activities.

District 2 Executive Committee Meets at Pittsburgh

To transact matters of routine business and to plan for future District meetings, the executive committee of the Institute's Middle Eastern District met at the Keystone Athletic Club, Pittsburgh, Pa., Sept. 15, 1931. Representatives present were: *vice-president*, W. B. Kouwenhoven (Baltimore, Md.); *secretary*, G. S. Diehl (Baltimore, Md.); *assistant national secretary*, H. H. Henline (New York); *Section chairmen*, R. R. Krammes (Akron, Ohio); K. A. Hawley (Baltimore, Md.); E. S. Fields (Cincinnati, Ohio); G. A. Kositzky (Cleveland, Ohio); P. R. Urich (Erie, Pa.); Morland King (Lehigh Valley); F. A. Connor (Pittsburgh, Pa.); R. M. Field (Sharon, Pa.); J. A. Dinwiddie (Toledo, Ohio); G. L. Weller (Washington, D. C.); *Section secretaries*,

R. A. Hudson (Akron, Ohio); John Wells (Baltimore, Md.); J. A. Noertker (Cincinnati, Ohio); F. E. Snell (Cleveland, Ohio); R. Mallory (Columbus, Ohio); C. V. Roberts (Erie, Pa.); J. L. MacBurney (Philadelphia, Pa.); T. Spooner (Pittsburgh, Pa.); *alternate for secretary*, F. R. Mueller (Washington, D. C.).

As District representative on the national nominating committee, F. J. Chesterman (A'20-F'22) of Pittsburgh, Pa., was elected and authorized to go uninstructed. As members of the District coordinating committee, in addition to the District vice-president and secretary, K. A. Hawley (Baltimore, Md.) G. L. Weller (Washington, D. C.) F. A. Connor (Pittsburgh, Pa.) and C. N. Johnson (Philadelphia, Pa.), Section officers, and Prof. J. T. Walther (Akron, Ohio) as student Branch counselor, were elected. To round out the District meeting committee, which is composed of the district coordinating committee and two members from the Section where the next proposed District meeting is to be held, K. A. Hawley, chairman of the Baltimore Section, appointed A. F. Bang and L. G. Smith.

To serve District No. 2 as a prize award committee, Dr. M. G. Lloyd, Washington, D. C., was elected to serve as chairman, along with Prof. T. D. Owens, (Cleveland, Ohio) and W. A. Hillebrand (Barberton, Ohio).

The District committee is planning for a 1932 fall District meeting to be held in Baltimore, and contemplates the possibility of a District meeting at Akron, Ohio, for the spring of 1933. Ways and means of stimulating Section activities were discussed and the desirability of pursuing unrelenting membership activities was emphasized.

N. Y. Section to Hear About Suburban Electrification

Suburban electrification will be the topic for discussion at a meeting to be held at 7:30 p. m. on Tuesday, November 10, 1931, in Room 1 of the Engineering Societies Building, 33 West 39 Street, New York, N. Y., by the Transportation Group of the Institute's New York Section.

G. A. Wright of the Reading Company will give a talk on the Reading electrification, describing the construction and illustrating with moving pictures the interesting steps leading up to inauguration of service.

R. M. White of the Delaware, Lackawanna & Western Railroad will outline the experiences of a railroad which has for the past year operated suburban traffic under electric power.

Future Section Meetings

Akron

November 10, 1931—Oil Purification, by R. P. Dunmire, Buckeye Laboratories, Inc.

December 8, 1931—Television, by J. O. Perrine, American Tel. & Tel. Co.

Cleveland

November 19, 1931—Engineering in Russia, by Arthur G. McKee, President, Arthur G. McKee & Co.

December 17, 1931—Behind the Scenes, by Dr. Zay Jeffries, metallurgical engineer and consultant; W. L. Enfield, manager, incandescent lamp development laboratory. Both of these speakers are with the General Electric Company at Nela Park. Joint meeting with the Illuminating Engineering Society.

Dallas

November 23, 1931—Communications, by H. S. Osborne, American Tel. & Tel. Co.

Detroit-Ann Arbor

November 10, 1931—Power System Stability, by Robert Treat, General Electric Company. Meeting to be held at Jackson, Mich.

December 1, 1931—Subject to be announced later. Meeting to be held at Detroit Edison Auditorium.

Lehigh Valley

November 13, 1931—Power System Operation, by George M. Keenan, superintendent of the Pennsylvania-New Jersey 220-kv. Interconnection. Arrangements have also been made to visit and inspect the Service Depot of the Metropolitan Edison Co. in Reading.

Pittsburgh

November 10, 1931—Lightning Protection of Overhead Transmission Systems, by W. W. Lewis, General Electric Co.

December 8, 1931—Recent Developments in Electrical Research, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co.

Rochester

November 9, 1931—Experimental Visual Broadcasting, by A. B. Chamberlain, Columbia Broadcasting System;

Advances in Ultra Short Wave Transmission and Reception, by Edward Karplus, General Radio Co. Joint meeting with the I. R. E.

Toledo

November 20, 1931—Power Transformer Design and Tap Changing Under Load, by L. H. Hill, Allis Chalmers Mfg. Co.

Talk by James Dinwiddie, Westinghouse Electric & Mfg. Co.

December 9, 1931—Television, Its Fundamental, Physical and Psychological Principles, by J. O. Perrine, American Tel. & Tel. Co.;

Protective Relays, by J. H. Hunt, Toledo Edison Co.

Past Section Meetings

Boston

Inspection trip through the new Herald-Traveler Building. October 3. Attendance 300.

Chicago

Industrial Russia, by John M. Carmody, editor, Factory & Industrial Management. Dinner preceded the meeting. Joint meeting with the Western Society of Engineers and the A.S.M.E. September 21. Attendance 650.

Cincinnati

Lighting for Health—Latest Types of Equipment and Methods of Application, by Carl E. Egeler, General Electric Co. Dinner preceded the meeting. September 10. Attendance 62.

Dallas

The Use of Electricity and Radiant Energy in Medicine, by Dr. Charles L. Martin. Illustrated with slides, charts, and demonstrations. September 26. Attendance 81.

Denver

Demonstration of Induction Between Power and Telephone Circuits, by H. R. Huntley, American Tel. & Tel. Co. September 9. Attendance 205.

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed motion pictures which he had taken during his recent world tour. Dinner preceded the meeting. September 25. Attendance 15.

Detroit-Ann Arbor

Aviation, by William B. Stout, Stout Engineering Laboratories. Mr. Stout described some of the difficulties which

have been met in developing commercial aviation. Annual dinner meeting. September 15. Attendance 150.

Erie

Unemployment from Technological Standpoint, by Laurence A. Hawkins, General Electric Company. September 15. Attendance 75.

Houston

Production and Application of Light, by V. O. Clements, Westinghouse Electric & Mfg. Co.;

Electrical Equipment for Oil Field Operation, by I. T. Hockaday, General Electric Co.;

The Responsibility of Members of the A.I.E.E. to Their Local Section, by J. E. Sheehan, Houston Lighting & Power Co.;

Résumé of Lightning Protection on Transmission Lines, by E. J. Shimek, Rice Institute. The above papers were taken from articles published in Electrical Engineering and each was presented in approximately twenty minutes. Dinner preceded the meeting. September 17. Attendance 30.

Los Angeles

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Elec. & Mfg. Co.;

An Electrical Engineer's Part in Aviation, by C. F. Green, General Electric Co. Past-chairman H. W. Hitchcock and chairman P. S. Biegler gave brief reports of the Asheville and Lake Tahoe conventions, respectively. Dinner preceded the meeting. September 8. Attendance 96.

Louisville

Recreational meeting. September 25. Attendance 69.

Memphis

Tata Hydroelectric Development in West India, by M. Eldredge, Memphis Power & Light Co. September 8. Attendance 48.

Mexico

Dinner meeting at which the officers for the term 1931-32 were announced as follows: E. F. Lopez, chairman; L. Castro, secretary; F. Aubert, treasurer. September 22. Attendance 40.

Minnesota

A. A. Kearney, Manilla Electric Lighting & Power Co., gave a talk on interesting phases of his experiences in the Orient. September 22. Attendance 44.

Niagara Frontier

Some Engineering Features of the Niagara-Hudson System, by Norman R. Gibson, Niagara-Hudson Power Co.;

The New 60-Cycle Distribution System in Buffalo, by R. T. Henry, Buffalo, Niagara & Eastern Power Corp. Dinner was held at the Hotel Statler preceding the meeting. September 18. Attendance 120.

Oklahoma City

Taping of High Voltage Cable Joints, by R. Schaeffer, Byllesby Engineering & Mgt. Corp.;

Piloted Ground Wire Study, by J. D. Browder, Oklahoma Gas & Electric Co.;

The Asheville Convention, by C. T. Almquist, University of Oklahoma, and delegate of the Section to the summer convention;

The Kansas City District Meeting, by F. J. Meyer, Oklahoma Gas & Elec. Co. Dinner preceded the meeting. September 21. Attendance 70.

Pittsburgh

Inspection trip through the plants of the Pennsylvania Rubber Co. and the Paramount Rubber Co. Joint meeting with the Engineers' Society of Western Pennsylvania. September 15. Attendance 195.

Portland

Recollections, by O. B. Coldwell, General Electric Co. Dinner meeting. September 22. Attendance 55.

St. Louis

Social meeting. September 23. Attendance 205.

San Antonio

F. A. Dale, Emory Peck & Rockwood, spoke about the Hamilton Dam under construction on the upper Colorado river. Illustrated with slides. September 22. Attendance 42.

San Francisco

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed several films taken on his recent trip around the world. Meeting was preceded by a dinner. September 11. Attendance 82.

Some Thoughts on Waves, by O. B. Blackwell, American Tel. & Tel. Co. Illustrated with slides. Dinner meeting. October 2. Attendance 156.

Sharon

Lightning Surges on Transmission Lines, by J. J. Torok, Westinghouse Electric & Mfg. Co. October 6. Attendance 112.

Spokane

Report of Summer Convention and Brief Description of Papers Presented at Asheville, by L. A. Traub, Home Tel. & Tel. Co., and delegate of the Section. September 25. Attendance 7.

Toledo

Results of Seven Years Radio Interference Investigation, by Fred C. Helwig, Toledo Edison Co.;

Symmetrical Components, Theory, and Application, by B. C. Harker, Westinghouse Elec. & Mfg. Co. September 25. Attendance 55.

Toronto

Economics, A Challenge to the Engineer, by Roy V. Wright, president A.S.M.E. Short talks by S. G. Porter, president, Engineering Institute of Canada, and L. B. Chubbuck, Canadian Westinghouse Co., Ltd., vice-president, Canada District No. 10, A.I.E.E. Joint meeting with the A.S.M.E. and Engineering Institute of Canada. October 2. Attendance 125.

Utah

Some Institute Problems, by C. E. Skinner, president of the A.I.E.E., and assistant director of engineering, Westinghouse Electric & Mfg. Co. Doctor Skinner showed and explained some pictures of the Orient taken on the occasion of his visit to that part of the world when he was a delegate to the World Engineering Congress. September 15. Attendance 75.

Vancouver

Inspection trip to the new fire alarm headquarters. C. C. Mulligan gave a description of the central fire alarm system and conducted the party through the various rooms of the building. September 12. Attendance 30.

Past Branch Meetings

University of Arkansas

Study of Electrical Grounds, by Ned Muse, student. October 6. Attendance 33.

University of California

Prof. G. E. Beggs, Princeton University, gave a talk on the design of suspension bridges and other structures.

Illustrated. Joint meeting with the A.S.C.E. and A.S.M.E., to which the public was invited. September 3. Attendance 450.

Initiation banquet. Mokelumne River and Salt Springs Project, by O. W. Peterson, Pacific Gas & Electric Co.;

Joseph Henry, by Kenneth Hines, student. September 11. Attendance 41.

V. T. Johnson, chairman, gave a synopsis of his trip to the Pacific Coast convention held at Lake Tahoe in August. Prof. B. L. Robertson outlined his experiences with the General Electric Co. and at Pennsylvania State College. Prof. T. C. McFarland gave a talk on his trip to the east and his experiences at the Bell Telephone Laboratories, Inc., in New York. September 23. Attendance 57.

Clemson Agricultural College

Lighting Disturbances, by A. S. Teague, student;

A Talk on Telephones, by W. M. Thames, student;

Industries New Responsibilities, by L. C. Black, student;

Current Events, by J. M. Turner, student. Short talks by Prof. S. R. Rhodes, counselor, and G. C. Jones, student. October 1. Attendance 46.

University of Denver

Advantages of Student Membership, by Prof. R. E. Nyswander, counselor;

Fields of the A.I.E.E., by L. C. Trussler, Branch chairman. September 21. Attendance 18.

Film "Big Deeds." September 29. Attendance 31.

University of Kansas

Mr. Evanson, General Electric Co., gave a demonstrated lecture on carrier currents superimposed on power lines. Illustrated. October 1. Attendance 85.

University of Kentucky

Election of officers as follows: W. A. Hunter, chairman; H. F. Day, secretary-treasurer. September 16.

History, Aims, and Purposes of A.I.E.E., by Prof. W. E. Freeman, counselor, and vice-president, Southern District No. 4, A.I.E.E. September 30.

University of Louisville

Electric Welding, by W. Stafford, student;

Oil Filled Cables, by C. Best, student. July 17. Attendance 11.

Missouri School of Mines & Metallurgy

Election of officers as follows: W. O. Woods, chairman; Wm. Pickles, vice-chairman; H. W. Short, secretary-treasurer. Three films shown as follows: "Pictures by Wire," "Voices Across the Sea," and "That Big Little Fellow." September 30. Attendance 18.

University of Missouri

Prof. M. P. Weinbach, counselor, spoke in detail concerning the purpose and organization of the A.I.E.E. Election of officers as follows: James E. Shepherd, chairman; Alfred L. Coffman, vice-chairman; Leslie E. Bates, Jr., secretary-treasurer. September 30. Attendance 50.

University of Nebraska

General discussion of programs for future meetings. September 30. Attendance 9.

Newark College of Engineering

Magnetic Testing, by Mr. Shedd, student. Election of officers as follows: Edward Olsta, president; John G. Woehling, vice-president, Albert E. Day, secretary; George Barker, treasurer. September 21. Attendance 29.

University of North Carolina

Talks on the advantages of student enrolment in the A.I.E.E. by Profs. J. E. Lear, Bennett, and E. W. Winkler. October 1. Attendance 40.

Pennsylvania State College

Annual smoker. October 7. Attendance 90.

Pratt Institute

W. H. Sutton, chairman, gave a brief account of last year's activities and explained the purposes of the Student Branch and the advantages of membership in the A.I.E.E. September 24. Attendance 32.

Inspection trip to the Hudson Avenue plant of the Brooklyn Edison Co. October 5. Attendance 43.

Rice Institute

Aims and Activities of the A.I.E.E., by Prof. J. S. Waters, counselor. September 30. Attendance 22.

University of South Carolina

Prof. T. F. Ball, counselor, gave a résumé of the activities at the Summer Convention held in Asheville, last June. October 2. Attendance 35.

Southern Methodist University

The advantages of student enrolment in the A.I.E.E. were presented by Prof. H. F. Huffman, counselor. Election of officers as follows: J. V. Melton, chairman; R. W. Smith, vice-chairman; R. L. Allen, secretary-treasurer. September 9. Attendance 34.

General discussion of plans for future meetings. October 7. Attendance 15.

University of Vermont

Life and Work of Faraday, by Donald E. Child, chairman. September 28. Attendance 20.

Virginia Military Institute

The Life of Faraday, by S. N. Garret, student;

Photographic Aerial Surveying, by W. R. Fuller, student;

Electric Welding, by L. DeCamps, student;

Life of George Westinghouse, by S. R. Chisman, student. Prof. S. W. Anderson, counselor, explained the organization and purpose of the A.I.E.E. and welcomed the new students. September 26. Attendance 76.

Virginia Polytechnic Institute

Discussion of Branch activities for the coming year. September 24. Attendance 21.

Expansions and Improvements Being Made in Electrical Power Plants, by R. C. Hoffman, student;

Communication, by M. W. Bowery, student. P. H. Cross elected secretary. October 1. Attendance 45.

West Virginia University

Election of officers as follows: A. W. Friend, president; D. C. Kennedy, vice-president; Philip Skaff, secretary, H. V. Locker, treasurer. September 21. Attendance 30.

The following talks were given by students:

Ford Changes from D-C. to A-C., by L. Palmer;

Railway Electrification, by D. C. Kennedy;

Electric Lighting Before Edison, by R. H. Colborn;

Pressure Indicator on a Diesel Engine, by J. Kayauha;

Pentode Vacuum Tubes, by A. W. Friend. Prof. A. H. Forman, counselor, gave a short talk on the benefits of student enrolment in the Institute. September 28. Attendance 30.

The following talks were given by students:

Progress in Engineering, by L. P. Kerwin;

Power Exploitation in Switzerland, by W. McMillian;

Copper, by R. W. Blair;

Power Transmission in South Africa, by L. Post;

Injuries Produced by Surge Discharges, by J. L. Simpson;

X-Rays, by J. E. Wallace;

Vacuum Tubes, by F. Q. Brown;

Short Radio Waves, by N. I. Hall. October 5. Attendance 30.

Employment Notes

Of the Engineering Societies Employment Service

Position Available

SALES ENGINEER. An electric cable manufacturer wants a man to manage one of its branch sales offices. He must have a thorough electrical engineering education, either university or practical training. He must have had sales experience in the industrial field. He must have had sufficient executive experience to handle and direct men. If you do not have all three requisites please do not apply. If you have here is a real opportunity. W-2758 C.

Men Available

ELECTRICAL ENGINEERING GRADUATE, age 22, B. S. in E. E. from well-known engineering college. Ten months' experience on construction. Desires employment with utility, engineering, or manufacturing concern. References furnished. Available upon short notice. C-9885.

ELECTRICAL ENGINEER, 33, married, B. S. in E. E. Ten years' experience as engineer with utility company. Familiar with design of lines and stations; accounting set-ups; executive duties and powers; modern business practise; now studying corporation law. Available at once. C-4734.

1931 GRADUATE of five-year cooperative school in electrical engineering. E. E. degree, age 23, single. Cooperative experience includes machine shop practise, telephone central office trouble shooting, and experience with large municipal fire alarm system. Desires position with manufacturing concern or public utility. Willing to start at bottom. Location, Middle West preferred, but elsewhere satisfactory. C-9825.

ELECTRICAL ENGINEER, graduate Lehigh University '22. Experienced in all kinds of construction, transmission work, power plants, substations, etc., chiefly as draftsman laying out such work. Familiar with electrification in anthracite fields. Willing to accept drafting, engineering or any other electrical position. Eastern States preferred but anywhere considered. C-9723.

ELECTRICAL ENGINEER, technical school graduate. Thoroughly familiar with the layout and design of power and substations having held position of engineering supervisor with large public utility for the past ten years. Experienced in organization and maintenance of meter test department. Speaks Portuguese; seven years' foreign experience. Available at once. C-9886.

1931 ELECTRICAL ENGINEERING GRADUATE of midwestern university. Age 22, single. Experience limited but includes technical work acquired from summer employment with street railway and ceramic industry. Courses taken include vacuum tube control devices and radio. Desires position with manufacturing or engineering concern. C-9879.

ASSOCIATE ELECTRICAL ENGINEER, 37, married. Twelve years with Westinghouse; apprentice course, sales and shop. One and one-half years western electrical engineering department, writing inspection methods instructions. Knowledge of oscillograph testing and meters. C-8817.

ELECTRICAL ENGINEER, 21, single, B. S. degree in E. E., A & M College of Texas, 1931, holder of government broadcast class operator's license. Two years' experience in radio work. Desires position in radio or telephone industries. Available at once. Will go anywhere. C-9588.

GRADUATE ELECTRICAL ENGINEER, 22, single, B. S. degree in E. E., University of North Carolina, 1931. Four years' experience in radio work. Desires position in radio or vacuum-tube industries; excellent references; location immaterial; available upon two weeks' notice. C-9896.

1924 GRADUATE ELECTRICAL ENGINEER available at once. Six years' research and practical experience on insulation and cables of all kinds. Two years' work on inductive coordination. Best of references. C-2282.

1931 GRADUATE ELECTRICAL ENGINEER, B. S. degree, single, age 22, American. Desires position in the electrical industry with an opportunity for advancement. Location, immaterial. Available immediately. C-9909.

1930 ELECTRICAL ENGINEER, Drexel Institute, 24, single, in very good health, 1½ years' experience in making complete electrical tests on distribution, power and rectifier transformers, and metering equipment. Also G. E. Test floor experience. Desires position with public utility, or industrial concern. Available at once. Location, immaterial. C-9913.

CONSULTING ENGINEER, New York City, having good connections with companies building high voltage switching stations, seeks to represent in the East first class concern manufacturing equipment for same. C-9332.

TECHNICAL GRADUATE in electrical engineering, 29, single, 1½ years G. E. Test; over ten years' experience with leading electrical company in repair, testing of electrical apparatus. Desires position in testing and experimental work on motors, generators, etc. Future prospects considered more important than initial salary. Best of references. Available short notice. C-8778.

RECENT GRADUATE wants to use scientific and engineering knowledge as background for commercial and management activities. Desires connection with leading concern, salary secondary. Foreign languages, long residence abroad, good references. C-9920.

GRADUATE ELECTRICAL ENGINEER, 1925, 28, single, year and a half G. E. Test, two years electrical construction in plants and substations for large utilities, one year superintendent electrical construction in steam plant and substations in Brazil. Desires position with utility on construction or operation work. Location, immaterial. C-4770.

PLANT MANAGER OR CONSTRUCTION SUPERINTENDENT. Graduate electrical engineer, 39 years of age, with some experience in heavy chemicals. Fifteen years of varied experience in utility operation, factory management, production engineering, radio and construction. Available at once. Location, immaterial. B-7340.

ELECTRICAL ENGINEER, B. S. E. E. degree from southern university, 1931, age 21, single. Desires position with manufacturing concern offering a future, or as instructor in electrical engineering. Location, immaterial. Available at once. C-9607.

ELECTRICAL ENGINEER, 28, single. Graduate Georgia Tech '29, B. S. in electrical and civil engineering. Westinghouse Test floor, engineering school and design school. One year's experience in turbine generator design including development work. Desires position with future. Location immaterial. Available immediately. C-9923.

ELECTRICAL ENGINEER, B. S. in E. E., Case '29, age 25, single. Two years' varied experience with General Electric Company. Desirous of position with opportunities. Available immediately. C-9918.

1931 ELECTRICAL ENGINEERING GRADUATE, age 22, single, B. S. in E. E. at Carnegie Tech. Tau Beta Pi. Experienced in drafting and power substation construction. Desires position in railroad electrification or operation, or with other power engineering firm. Location, immaterial, Available immediately. C-9925.

GRADUATE ELECTRICAL ENGINEER, 1929, Ohio State University. Age 26, married. Tau Beta Pi. One year Westinghouse student course. Sixteen months motor engineering, mostly synchronous motor design. Motor and control test experience. Good references. Available immediately. C-9924.

ELECTRICAL ENGINEER, Pratt graduate 1931. Some experience with resistor units, also with vacuum and photocell tubes. Has had office work in graphs, data, reports. Interested in airport lighting, television, and sound. Eastern location preferred. C-5636.

PATENT ATTORNEY, graduate engineer, connected with a well-known firm specializing in foreign applications. Desires to make a new connection. Familiar with design and development of small electrical and mechanical parts. C-846.

ELECTRICAL ENGINEER, 22, single, University graduate '31. Desires junior position in test or design departments of power machinery manufacturing concern. Experience limited. Location preferred, Eastern. Available upon short notice. C-9447.

ELECTRICAL ENGINEER, 40, married, graduate Federal Technical University, Zurich, Switzerland. Experienced in design, construction, operation of power stations, substations, transmission lines, purchasing electrical equipment, duct lines and cable work, railroad electrification, catenary design, extensive knowledge, pleasing personality. Available now, location, immaterial. C-683.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering: cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense, and cost analysis. Capable organizer. Profitable assistant to busy executive. Prefers East. Consider any proposition. B-9122.

ELECTRICAL ENGINEER, graduate recognized southern university, 34, married, G. E. Test; broad experience utility field, particularly underground systems, including

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design, maintenance of low voltage a-c. networks. Desires position with utility with responsibility for design or maintenance of underground, overhead system, or manufacturer working on design problems. Location preferred, Middle West or Southwest. C-1191.

PHYSICIST, middle-aged, experience in industrial research, supervision of research, executive work and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent American universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available upon short notice. C-7900.

ELECTRICAL ENGINEER, 33, married, graduate of Worcester Polytechnic Institute, 1921, B. S. in E. E. Two years' experience in railway work, eight years in engineering, design, purchase of equipment, and construction of power stations, switching stations and substations. Desires sales engineering work. Location, New York Metropolitan preferred. Available immediately. C-9928.

GRADUATE ELECTRICAL ENGINEER, B. S. in E. E. 1928, M. S. in E. E. 1929. Completed Westinghouse Graduate Student and Electrical Design school courses. One year's experience induction motor designer; six months laboratory instructor. Desires position as instructor on university staff or engineer with manufacturing concern. Location, United States. C-9936.

ELECTRICAL ENGINEER, M. S. 1931 from M. I. T. G. E. Test including railway. American, age 22, married. Desires connection with electrical company or public utility or as instructor in electrical engineering, physics, or mathematics. Location, immaterial. C-9942.

GRADUATE ELECTRICAL ENGINEER, 28, single, B. S. in E. E. from University of Minnesota, eighteen months General Electric Test, twenty-three months telephone and telegraph engineering. Desires position with manufacturing or public utility company. Location and remuneration considered secondary to opportunity offered for future. Available at once. C-9285.

ELECTRICAL ENGINEER, 22, B. S. E. E., 1930. Desires connection with public utility, electrical or radio manufacturing company. G. E. Test experience. Six months work with vacuum tubes. Experience with large motors. Location, immaterial. C-9806.

EXECUTIVE, Industrial physicist, technical graduate with diversified research experience and excellent engineering training, desires position with American organization. Will also consider opening as assistant to able engineer or business executive. B-8987.

COMMUNICATIONS ENGINEER Twenty years' telephone, telegraph, and radio inside and outside construction and maintenance experience, mostly abroad. Considerable knowledge modern high speed telegraph systems, relays and circuits. Wire experience on wiring diagrams. Switchboards, etc. Could economically modernize communication systems preferably abroad. C-8805.

ELECTRICAL ENGINEER, 23, degree B. S. in E. E. University of New Hampshire '30. Fourteen months G. E. Test and general course. Test experience in transportation, motors, and generators and vacuum tubes. Nine months' summer work in main line electric railway shops. Interested in any engineering work. Available on short notice. C-9859.

GRADUATE ELECTRICAL ENGINEER, age 28, married. Four years' experience in power plant and substation design. Eighteen months in signal department of a rapid transit railroad. Western Electric training course for switchboard engineer. Can refer freely to past connections. Location immaterial. Available now. C-9944.

GRADUATE ELECTRICAL ENGINEER, 42, married. Sixteen years' experience in design of small and fractional horsepower motors including polyphase different types of single-phase now on market and d-c. motors. Considerable experience in manufacturing, testing and cost analyzing. C-9951.

COST REDUCTION ENGINEER, cooperative engineering graduate, 1927, B. S. in E. E., desires position with manufacturer of electrical or mechanical products. One requiring experience in plant layout, improvements, material handling, machine shop practises, chart and statistical analysis. Would also consider technical report work with an industrial appraiser. C-9916.

ELECTRICAL ENGINEER, 45, university graduate, experienced in the various branches of electrical engineering work of power companies, including work for industrial customers, desires position with power company or manufacturer. Permanent position desired, but will consider temporary work. B-1923.

ELECTRICAL ENGINEER, age 39, married, technical graduate, B. S. E. E. 1913. Eighteen years' experience in the public utility field. For the past eight years chief draftsman in charge of large department doing substation and power house design. Seeks new connection as company is dissolving. Available immediately. C-9953.

ELECTRICAL ENGINEER, 33, with eight years' experience in erecting and installing electrical machinery and control apparatus. Also previous factory testing. C-9954.

ELECTRICAL ENGINEER, 21, single, 1931 graduate with B. S. in E. E. Member of honorary fraternity in college and won scholarship three consecutive years. Summer experience with public utility. Interested in any electrical engineering field including vacuum-tube work. Available at once. Location, New York preferred, but not essential. C-9467.

RADIO ENGINEER, age 31, married, B. S. in E. E. from one of the greatest Western universities. Has broad theoretical and practical experience in radio engineering. Available at once. New York City preferred. C-6734.

PUBLIC UTILITY ENGINEER, technical college graduate, age 37. Twelve years' diversified experience in all branches of the utility business. Valuation work, rate investigation, cost analysis, statistical and financial research, engineering and sales work. Services offered to any company requiring a trained public utility man. B-9782.

1931 ELECTRICAL ENGINEERING GRADUATE, age 22, B. S. E. E. in well-known engineering college. Desires connection with manufacturing or public utility concern. Four months' experience with a large power company. Michigan or bordering states preferred. Available immediately. C-9949.

ELECTRICAL ENGINEER, 35, single, M. I. T., general business experience, hydroelectric station operator one year; taught E. E. in university 1½ years; preparation of instruction books for electrical and mechanical apparatus 3½ years. Desires position in research and development or as instructor. New York City preferred but not essential. Available immediately. C-2481.

GRADUATE ELECTRICAL ENGINEER, 25, single, B. S. in E. E., 1930 Mid West college. One year G. E. Test including work on railway motors, control equipment and locomotives. Railway or public utility work preferred. Location anywhere. Salary secondary to opportunity. References. Available immediately. C-9958.

GRADUATE ELECTRICAL ENGINEER, 23, of Rensselaer Polytechnic Institute, desires position in public relations department of power and light utility company. Two years of varied power and light experience. Location, immaterial. C-9957.

DESIGN ENGINEER, college graduate, 38, married. Nine years electrical substation and power house design, with switchboards, wiring diagrams, and all other important items. Five years testing engineer power station and research laboratories. Speaks Spanish, German, and Hungarian fluently. Available for immediate offer. Location, U.S.A. or any foreign country. C-9128.

ELECTRICAL ENGINEER, 1930 graduate; cooperative experience on machinery layout and power wiring; recently employed elevator appliance design, layouts, test, reorganization. Eastern Pennsylvania preferred. C-9963.

ELECTRICAL ENGINEER, 35, married with 15 years' experience. One year G. E. Test. Two years U. S. Navy. Twelve years with manufacturer of control specialties. Vast experience with elevators and elevator accessory equipment. Desires engagement with elevator manufacturer or one manufacturing a varied line of control apparatus. Locate anywhere. C-9956.

ELECTRICAL ENGINEER, 30, desires new location. Responsible, keen, with a good record covering 8 years' experience in the design, construction and operation of generation, transmission and distribution. Also successful experience in rating, public relations. Special studies made of rural distribution and service. C-9959.

SALES ENGINEER, 22, single with automobile. B. S. in E. E. Georgia Tech., 1929. Experience in all departments of a Southern utilities corporation. Eight months' sales experience. Available anytime, anywhere. C-9965.

INDUSTRIAL ELECTRICAL ENGINEERING GRADUATE, Pratt Institute 1931, 21, single. Specialized in high frequency circuits. Three years' experience in the radio field. Desires work with radio or sound concern. Available immediately. Location, East. C-9964.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E. University of Alabama. Desires position with utility, construction, manufacturing company. Location immaterial. Experienced in power plant and building installation and industrial control, having been employed for eight summer months and one full year first as electrician's helper and then as first class electrician. C-9446.

SALES EXECUTIVE: with electrical training. Seven years' experience in sales engineering and sales through distributors. Well acquainted with sales conditions in various parts of country. Willing to tackle difficult job. C-5431.

ELECTRICAL ENGINEER, 1931 graduate State University, B. S. degree E. E. and M. S. degree I. E. Single, 24. Experienced electrician on construction work with limited experience as estimator in same field. Desires connection with engineering, manufacturing, or large contracting concern. Any location acceptable; South America preferred. Available upon short notice. C-9970.

ELECTRICAL ENGINEER, graduate, married, 28, with wide experience in industrial plant electrical construction and maintenance; railway electrification; power plant design, estimating, and supervisory construction experience with electric contractor; cost analysis. Desires position with future. C-4428.

DISTRICT SALES MANAGER OR MANUFACTURER'S AGENT, experienced engineering representative, desires connection with high-grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

ELECTRICAL, MECHANICAL ENGINEER, college graduate with wide practical experience in power plant work and industrial electrical equipment. Desires connection, available immediately. B-2492.

Membership

Recommended for Transfer

The Board of Examiners, at its meeting of September 23, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Member

BURNETT, JAMES HENRY, asst. engr., Brooklyn Edison Co., Brooklyn, N. Y.

CORY, SAMUEL I., telephone engr., American Tel. & Tel. Co., New York

CURRIE, FRANK L., engg. asst., Western Union Telegraph Co., New York.

FITZGERALD, EDWARD B., elec. engr., The J. G. Brill Co., Philadelphia, Pa.

FOUST, CLIFFORD McCLAIN, elec. engr., General Elec. Co., Schenectady, N. Y.

GIERING, PERCIVAL L., consulting elec. engr., City of Boston, Transit Dept., Boston, Mass.

GILMAN, WILLIAM F., executive adviser to management, Kwang Tung Electric Supply Co., Canton, China; residence, Belgrade Lakes, Maine.

HANNAFORD, EARLE S., supervisor of education and training, American Tel. & Tel. Co., Atlanta, Ga.
JACOBY, S. CLIFFORD, supt., transmission and distribution, Montaup Electric Co., Fall River, Mass.
LONGFIELD, CLAUDE M., electrolysis engr., State Electricity Commission of Victoria, Victoria, Australia.
McCLENAHEN, R. A., engg. asst., United Engineers & Constructors, Inc., Newark, N. J.
OSBORNE, R. W., president, Osborne Electric Co., Toronto and Niagara Falls, N. Y.
PARRACK, VASCO R., engr., Tennessee Public Service Co., Knoxville, Tenn.
SCHLENKER, VESPER A., consulting acoustical engr., New York.
SMITH, JR., S. ARCHIBALD, asst. engr., transmission, Public Service Electric & Gas Co., Newark, N. J.
WEIL, JOSEPH, instructor, consulting engr., University of Florida, Gainesville, Fla.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before November 30, 1931.

Arthur, A. L., Syska & Hennessy, New York, N. Y.
Baxter, F. I., Kansas City Public Service Co., Kansas City, Mo.
Beck, Wm. O., Kelly Island Lime & Transport Co., Clay Center, Ohio
Bennett, W., Loew's Columbia, Warner Bros., Tivoli, Universal Pictures Corp., Rialto Theatres, Washington, D. C.
Brown, T. A. (Member) Madison Gas & Electric Co., Madison, Wis.
Brucker, R. K. (Member) J. G. Wray & Co., Chicago, Ill.
Cartmell, R. H., 2008 E. Live Oak, Temple City, Calif.
Collins, I. W., Pacific Gas & Electric Co., Oakland, Calif.
Crossley, H. R., Dominion of Canada, St. John, N. B., Can.
Dahlem, J. G., Richard Kaupert, Milwaukee, Wis.
Danko, J. T., University of Pittsburgh, McKeesport, Pa.
Den Braven, G., L. Bamberger & Co., Newark, N. J.
Dilts, C. B., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Dunklin, G. T. (Member) Westinghouse Elec. & Mfg. Co., New York, N. Y.
Edwards, L. C., Pacific Gas & Electric Co., Emeryville, Calif.
Fox, L. H., Mississippi A. & M. College, A. & M. College, Miss.
Goodhue, Wm. M., Harvard University, Cambridge, Mass.
Griffith, L. A., Emerson Elec. Mfg. Co., Richmond Heights, Mo.
Hartman, E. R. (Member) Telephone Bond & Share Co., Kansas City, Mo.
Henderson, R. M., National Light & Power Co., Moose Jaw, Sask., Can.
Hottle, W. M., Western Electric Co., Kearny, N. J.
Howe, P. B., Philadelphia Electric Co., Philadelphia, Pa.
King, F. H., Holyoke Gas & Electric Dept., Holyoke, Mass.
Kitchen, W. A., Oklahoma Gas & Electric Co., Oklahoma City, Oklahoma
Klitten, A. H., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Lloyd, T. C., Antioch College, Yellow Springs, Ohio
Loewe, R., University of Wisconsin, Madison, Wis.
Lundelius, O. E., City of Austin, Austin, Tex.
Miller, J. F., Louisville Gas & Elec. Co., Louisville, Ky.
Milligan, L. S., Long Island State Park Commission, Babylon, L. I., N. Y.
Omar, S., General Electric Co., Schenectady, N. Y.
Poppe, F. W., 1282 Shakespeare Ave., New York, N. Y.
Porter, H. F. (Member) Allegheny Steel Co., Brackenridge, Pa.
Randel, E. S., Southwestern Bell Telephone Co., Kansas City, Mo.
Rowley, R. A., 23 Girard Ave., Hartford, Conn.
Sargent, F. J., Madison Gas & Electric Co., Madison, Wisconsin
Sewell, F. N., Texas Power & Light Co., Dallas, Texas
Sklar, H. L., Micamold Radio Corp., Brooklyn, N. Y.
Urbany, J. E., Coyne Electrical School, Chicago, Ill.
Vidmar, P. J., Illinois Testing Laboratory, Chicago, Ill.
Walch, D. E. (Member) General Electric Co., Boston, Mass.
Watts, J. H., Westinghouse Elec. & Mfg. Co., San Antonio, Tex.
Whitmore, R. E., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
43 Domestic

Foreign

Castells, C. L., Ericsson Sudamericana, Buenos Aires, Argentina, So. America
Dunlop, R. P., Hong Kong Electric Co., Ltd., Hong Kong, China
MacAlpine, R. W., British Thomson-Houston Co., Ltd., Rugby, Eng.
Repetto, E. L., Rivadavia 3079, Dto. G, Buenos Aires, Argentina, So. Amer.
Sakakibara, K., Hitachi Electrical Engineering Works, Hitachi, Ibaraki-ken, Japan
Satyanarayana, P., L. M. & S. Railway, Stonebridge Park, London, England
6 Foreign

November 1931

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All papers presented at the South West District (No. 7) Kansas City Meeting

Number	Author	Title
☐ 31-132	J. Slepian and L. R. Ludwig	Backfires in Mercury Arc Rectifiers
☐ 31-133	H. W. Collins, E. E. Piepho and J. J. Torok	Impulse Voltage Tests on a 4,800-Volt Distribution Substation
☐ 31-134	C. W. Nystrom	Tape-Armored Telephone Toll Cable
☐ 31-135	O. B. Blackwell	The Time Factor in Telephone Transmission
☐ 31-136	E. K. Shively and G. S. Whitlow	Automatic Control for Variable-Ratio Frequency Converters
☐ 31-137	L. V. Nelson and E. L. Hough	Interconnection of the 25- and 60-Cycle System of the Union Electric Light and Power Company
☐ 31-138	J. N. Holsen	Forecasting Population for Engineering Purposes
☐ 31-139	W. D. Weidlein	Corona Energy Loss
☐ 31-140	E. J. Burnham	Overvoltage on Transmission Systems Caused by Dropping Load
☐ 31-141	J. Slepian and C. L. Denault	The Expulsion Fuse
☐ 31M8	P. N. Vinther	Electric Arc Welding in Building Construction
☐ 31M9	C. T. Almquist	Calculating Load Division in Distribution Systems
☐ 31M10	F. E. Sanford	Application of Primary Distribution Fuses
☐ 31M11	E. G. Newton	Fuse Cut-Outs—Their Design and Application for A-C. Distribution Circuits
☐ 31M14	C. C. McFarland	Advance Planning of Long Distance Telephone Facilities
☐ 31M15	P. H. Robinson	Effect of Wave Form on Operation of Induction Type Protective Relays

Papers presented prior to September 1931 and upon which articles in this issue are based

Number	Author	Title
☐ 31-64	J. E. Clem	Reactance of Transmission Lines with Ground Return
☐ 31-67	R. L. Davis	Power Equipment at New KDKA Station
☐ 31-94	G. Stamper and F. F. Ambuhl	Operating Experience with Automatic Stations
☐ 31-97	G. B. Shanklin and F. H. Buller	Characteristics of Oil Filled Cable
☐ 31-100	R. W. Atkinson and D. M. Simmons	Oil Filled Cable and Accessories
☐ 31-102	J. R. Eaton, J. K. Peck, and J. M. Dunham	Experimental Studies of Arcing Faults on a 75-Kv. Transmission System
☐ 31-108	D. W. Roper	Economics of High Voltage Cable
☐ 31-109	R. M. Stanley	Three Years' Operating Experience with Miniature Switchboard Supervisory Automatic Control

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Addresses Wanted

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BALAGUER, MANUEL M., c/o International Tel. & Tel. Co., 67 Broad St., New York, N. Y.

BUGG, VERNON M., 172 Elm Ave., Rahway, N. J.

CHILOFSKY, JOSEPH, 958 N. 7th St., Philadelphia, Pa.

CLARK, BERNARD, 79 Jenness St., East Springfield, Mass.

CORDIER, N. A., 126 Chatterton Pkwy., White Plains, N. Y.

FARNLOF, CHARLES G. T., 1318 Laketon Road, Wilkinsburg, Pa.

GARRISON, F. G., Internat'l Tel. & Tel. Corp., Buenos Aires, Arg., So. Amer.

KAMM, J. LLOYD, 1801 N. Lamar St., Dallas, Texas.

McLEAN, JAMES S., 190 Old Army Road, Scarsdale, N. Y.

MELSON, SYDNEY W., Yeatton Woolrich Road, Abbey Wood, London, S. E. 2, England.

MERRILL, J. L., 517 S. Orange St., Media, Pa.

MOUNTAIN, C. E., Burma Elec. Supply Co., Mandalay, Burma, India.

McCULLOCH, G. B., McVie Caterers, Ltd., Sydney, N. S. W., Australia.

PARR, J. C., 245-71st Street, Brooklyn, N. Y.

PIERSON, WALTER D., 4710 Locust St., Philadelphia, Pa.

PISTORIUS, L. H., 193 Jeppe St., Johannesburg, South Africa.

PRUDHAM, W. M., 100 Biddle St., Wilkinsburg, Pa.

SCHROCK, JOHN E., 3720 Main St., Lawrence Park, Erie, Pa.

STEMPFLE, FREDERICK, 8126 E. Vernor Highway, Detroit, Mich.

TATE, WILLIAM, Apartado No. 41, Publa, Mexico.

VORONOVSKY, T. G., 1162 Waverly Place, Schenectady, N. Y.

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A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during September are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

ESTIMATING BUILDING COSTS. By F. E. Barnes. 3rd ed. N. Y., McGraw-Hill Book Co., 1931. 656 pp., illus., diagrs., charts, tables, 7 x 5 in., cloth, $5.00.——A handbook for contractors and estimators which groups the information needed for determining the amount of labor needed for the various building operations, the current prices of labor and materials, and the cost of replacing buildings built between 1890 and 1926. The data are arranged for quick consultation, usually in tabular form. Labor hours and bills of materials are given. This edition has been thoroughly revised, and new chapters have been added on building insulation, storage silos and circular bins, concrete masonry and cement gun work. The author is Building Valuation Engineer of the New York Central Lines.

DIE CHEMIE DER KOHLE. By W. Fuchs. Berlin, J. Springer, 1931. 510 pp., diagrs., charts, tables, 10 x 6 in., cloth, 45 r. m. ——This monograph summarizes present-day views upon the chemistry of coal, lignite, and peat and is said to cover the literature down to March, 1931. Chapter one treats of the chemical composition of the coal-forming plants and of their decomposition. Chapters two to four treat of peat, lignite, and coal, discussing their petrographic, physical and chemical characteristics, their reaction to chemical and biological agents, behavior when heated, origins, etc. The final chapter gives methods of analysis and discusses their results.

BRONZE UND ROTGUSS, NACH DIN 1705. Berlin, VDI Verlag, 1931. 100 pp., illus., diagrs., charts, tables, 8 x 6 in., paper, 7 r. m. ——Contains the papers and discussions presented at a meeting of the Society of German Engineers devoted to the properties and use of the standard German bronzes and red brasses. The structure and properties of brass and bronze castings, and the standard compositions are discussed, and the experiences of various users are presented. Methods of testing are given. A bibliography for the years 1921 to 1930 is included.

PLASTICITY. Mechanics of the Plastic State of Matter. By A. Nadai with A. M. Wahl, asst. author. Germany. McGraw-Hill Co., 1931. 350 pp., 6 x 9 in., pamphlet. Price $5.00 ($4.00 to members of Founder societies). ——Translated from the German based on the original work of Doctor Nadai (formerly prof. of ap. mech., Univ. of Goettingen, but now with Westinghouse Research Lab.). The original work is amplified by the addition of new information, bringing together the observations of engineers, metallurgists, and physicists, regarding the plastic deformation of metals. It summarizes laws now available for a more exact prediction of stress distribution, and discusses the fundamentals of the theory of plastic flow, especially in metals. This is the first of a series of publications to be prepared by the Engineering Societies Monograph Committee.

PRINCIPLES OF ELECTRICITY. By L. Page and N. I. Adams, Jr. N. Y., D. Van Nostrand, Inc., 1931. 620 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.25.——Intended for undergraduates who have completed general courses in physics and the calculus, and for advanced students who wish a more comprehensive training in electromagnetism. The ordinary subject matter of electricity and magnetism is treated comprehensively, with unusual space devoted to the phenomena of high-frequency and electromagnetic waves. The book aims to fill the gap between elementary texts and advanced treatises that call for wide knowledge of higher mathematics.

INDUSTRIAL ORGANIZATION. By H. Rubey. Boston & N. Y., Ginn & Co., 1931. 308 pp., diagrs., charts, tables, maps, 9 x 6 in., cloth, $2.80.——A brief but comprehensive course covering such fundamentals of business as promotion, finance, management, organization, marketing, personnel, accounting, estimating, valuation, etc. The book is intended primarily to give the engineer some knowledge of business, in preparation for executive and managerial work; will be useful also to others who wish a general survey of this field.

ALTERNATING CURRENTS. By C. E. Magnusson. 4th edit. N. Y., McGraw-Hill Book Co., 1931. 685 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $5.00.——A text-book for undergraduate students which discusses the fundamental principles of the subject and shows their application to industrial problems. The changes in this edition include a rewriting and extension of the chapter on instruments, new chapters on systems of units and symbols, on mercury-arc rectifiers and on hot-cathode rectifiers and oscillators, as well as many new diagrams and illustrations.

ELECTRICAL EQUIPMENT. By H. W. Brown. 2nd edit., N. Y., McGraw-Hill Bk. Co., 1931. 586 pp., illus., diagrs., charts, tables, 9 x 6 in., $5.00.——This text-book is intended to teach students of engineering and others interested in the practical applications of electricity how to apply their knowledge of the theory of operation of electrical machines and the data given in handbooks to the equipping of shops, factories and industrial plants. The requisites of power plants and distribution systems, the characteristics of various motors, generators, transformers, regulating and protective devices, heating and welding apparatus, etc., are discussed and their suitability for various classes of work pointed out.

PROJECTING SOUND PICTURES. By A. Nadell. N. Y., McGraw-Hill Bk. Co., 1931. 265 pp., illus., diagrs., charts, 9 x 6 in., cloth, $2.50.——A book for theater men interested in the reproduction of sound. The principles underlying the mechanisms and circuits used for that purpose are described in a simple, practical manner, and attention is given throughout to the more common troubles of sound apparatus and methods of preventing them.

TECHNICAL WRITING. By T. A. Rickard. 3rd edit. N. Y., John Wiley & Sons, 1931. 337 pp., 8 x 5 in., cloth, $2.00.—— Interest in correct speech has become much more widespread since Mr. Rickard's book first appeared in 1919, and many text-books have appeared since that date. His work still remains, however, one of the most readable and best guides to the engineer who wishes to improve his power of expression. It may be recommended heartily. This new edition, prepared for the American Institute of Mining and Metallurgical Engineers, differs from the second edition only in sundry small corrections.

Selected Items From

Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Agricultural Machinery

ELECTRIC. Electricity and the Farmer, D. N. McHardy. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, pp. 319-320, 1 fig. Critical views by head of engineering department of Harper Adams Agricultural College on present position and future possibilities of application of electricity to agriculture; power for barn machinery and dairy; electricity for heating and cooking; part played by mobile tractor; possibilities of future.

Anemometers

An Anemometer for a Study of Wind Gusts, R. H. Sherlock and M. B. Stout. *Univ. Mich.—Eng. Research Bul.*, no. 20, May 1931, 38 pp., 25 figs. partly on supp. plate. New type of pressure-plate anemometer developed for use in general program of research on loading and strength of overhead lines; equipped with magnetic transmitter and uses oscillograph for recorder; can record accurately average wind velocity over intervals of time as small as 1/8 sec.

Busbars

Structural-Shape Conductors Show Increased Efficiencies, H. W. Papst and D. I. Bohn. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 418-419, 3 figs. In order to avoid shortcomings of tubes and bars new type of conductor consisting of structural shapes has been developed; new conductor is designed for currents of about 2,000 to 7,000 amperes at 60 cycles and combines various desirable properties of both tubes and bars; channel conductor ratings are given.

DESIGN. Le calcul des barres omnibus tubulaires aux points de vue mécanique et électrique (Electric Mechanical Strength Calculation of Tubular Busbars), R. Beyaert. *Electricien*, vol. 62, no. 1521, Aug. 1, 1931, pp. 348-353, 2 figs. Simple mathematical analysis with various numerical examples pertaining to aluminum and steel tubular busbars.

Cables

OIL-FILLED. The Theory of Oil-Filled Cable—II, G. B. Shanklin and F. H. Buller. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 523-530, 9 figs. Mathematical theory; loading, and steady-state temperature conditions; thermal transients; operational equations for transient temperatures; solution of operational equations; oil demand; systems of oil feed and reservoir characteristics.

RESERVOIRS. Oil-Pressure Reservoirs for Underground Cables, T. C. Aitchison. *Gen. Elec. Rev.*, vol. 34, no. 7, July 1931, pp. 410-415, 20 figs. Oil-pressure reservoirs are considered essential to successful operation of oil-filled and solid cables above 25 kv.; principal functions; various equipment and accessories are illustrated and described.

TELEPHONE. Securing Freedom from Cable Trouble, R. R. Rex. *Telephony*, vol. 101, no. 10, Sept. 5, 1931, pp. 30-31. Some helpful suggestions for securing freedom from telephone man's imaginary cable trouble; importance of periodic inspection and accurate records; discussion of causes of cable failure; suggested methods for locating trouble.

TESTING. The Electrical High-Pressure Testing of Cables and the Localization of Faults, J. Urmstom. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 983-1003 and (discussion) 1004-1012, 35 figs. Electrical high-pressure testing of cables, immediately after installation is completed, is discussed; author concludes that high-pressure d-c. test is useful and fulfils ordinary requirements; new connection for high-pressure d-c. testing set is described; methods of localization of more difficult kinds of faults are given; these show that there are very few faults which cannot be fairly accurately located.

UNDERGROUND MANHOLES. High-Pressure Manhole Washing Saves Expense of Opening Drains, C. B. Sharp. *Elec. World*, vol. 98, no. 7, Aug. 15, 1931, pp. 283-284, 1 fig. Forty plugged manhole drains was average per month reported on underground system of Detroit Edison Co. when manholes were being cleaned by hand; number has been reduced to 28 through use of water at 120-lb. pressure supplied from tank truck; also cleaning is done better, quicker and with fewer men.

Case Hardening

CARBURIZING. A New Method of Case-Hardening in an Electric Furnace. *Mar. Engr. and Motorship Bldr.*, vol. 54, no. 648, Sept. 1931, p. 351, 1 fig. Equipment introduced into England by Wild-Barfield Electric Furnaces, Ltd.; description of process, with costs of operation.

Cavitation

HYDRAULIC TURBINES. Cavitation of Large Turbine Runners, A. S. Robertson. *Elec. News*, vol. 40, no. 16, Aug. 15, 1931, pp. 35-36 and 38, 3 figs. Average maintenance costs amount to about $450 per runner per year using electric arc welding.

Circuit Breakers

TESTING. Testing Breaker Insulation by Power-Factor Methods, F. C. Doble. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, pp. 374-375. Author is reviewing work done by his organization in testing about 14,000 bushings and analyzing circuit-breaker insulation conditions by power factor method as applied to 11-kv. to 150-kv. equipment, and stressing advantages of a-c. test as compared with d-c. procedure and discussion by C. L. Dawes and C. A. Adams of Harvard, C. A. Powel of Westinghouse Electric & Manufacturing Co. and other outstanding men of electric manufacturing and power supply industry.

Circuits

ELECTRIC. Mathematical Analysis of Non-linear Circuits—I, A. Boyajian. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 531-537, 7 figs. In recent years, both troublesome problems and useful applications of networks with non-linear branches have been rapidly increasing, calling for more thorough and comprehensive analysis of phenomena involved; although physical or graphical analysis may prove sufficient for purpose, yet whenever possible mathematical analysis is highly desirable; more important non-linear circuits are: saturating circuits, arc circuits, and thermionic circuits; purpose of study is to develop technique that is applicable to all such circuits.

Transients in Grounded Wires Lying on the Earth's Surface, J. Riordan. *Bell System Tech. Jl.*, vol. 10, no. 3, July 1931, pp. 420-431, 4 figs. Voltages during transient conditions in grounded wire lying on earth's surface due to current in second grounded wire also on earth's surface are formulated for types of transient currents ordinarily obtained in a-c. and d-c. circuits; fundamental formula is for voltage due to unit step current, that is, current zero for time less than zero, and unity for time greater than zero; curves are given for function determining this voltage for wide range of values of its two parameters.

Conductivity

METALS. The Problem of the Electrical Conductivity of Metals, C. D. Niven. *Can. Jl. Research*, vol. 5, no. 1, July 1931, pp. 79-86. It is pointed out that mathematicians in their attempts to form theories of electrical conduction, do not lay emphasis on fact that at low temperatures, resistance, as a rule, does not vanish; in those cases in which it does, it vanishes suddenly; in view of this, question arises as to whether right model for conductivity metal is visualized; it is suggested that fundamentally a metallic atom is one in which electron configuration is incomplete.

Cooling

TURBO-GENERATORS. Hydrogen-Cooled Generators Have Economic Merit, M. D. Ross. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 408-409, 3 figs. In design of large turbo-generators next major step will be adoption of hydrogen gas as cooling medium; hydrogen is desirable as it has somewhat better heat transfer properties than helium, lower density and is available commercially at relatively low cost; density of commercial hydrogen is about 8 per cent that of air, so that windage losses, which are relatively high in turbo-generators, are reduced to negligible figure.

Dielectrics

TESTING. Dielectric Phenomena at High Voltages, B. L. Goodlet, F. S. Edwards and F. R. Perry. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 414, June 1931, pp. 695-727 and (discussion) 727-735, 36 figs. Breakdown of air, oil and solid dielectrics by normal-frequency impulsive and high-frequency voltages; large amount of original numerical data is given, covering entire range of voltage up to 1 million volts.

Education

ENGINEERING. Technical Education, H. L. Guy. *Engineering*, vol. 132, no. 3422, Aug. 14, 1931, pp. 201-202. Editorial comment on address before Oxford Summer School; author presses earnestly for closer correlation between works and technical schools; he suggests that summer school provides, perhaps easiest plan of any for keeping technical colleges in touch with practical problems.

RESEARCH. The Function of Research in Engineering Education, D. C. Jackson. *Science*, vol. 74, no. 1912, Aug. 21, 1931, pp. 183-187. Research not only has function in engineering education, but is integral part of properly conceived engineering education; investigatory spirit and achievement are more important attributes for engineering teacher than higher degrees; spirit for establishing research laboratories and foundations in engineering schools is presage of good educational spirit in schools. Before Soc. Promotion Eng. Education.

Electric Drive

COAL PREPARATION PLANTS. Electrification Problems in Modern Preparation Plants—I and II, E. J. Gealy. *Coal Age*, vol. 36, nos. 7 and 9, July 1931, pp. 346-348 and Sept., pp. 477-478 and 482, 3 figs. July: Review of development in design and construction; importance of observing certain fundamental principles; standardization of equipment. Sept.: Choice of motors, motor starters, pushbutton control, safety switches, power factor, welding, and lighting.

PUMPS, CENTRIFUGAL. Some Notes on Electrically Driven Centrifugal Pumps, H. E. Beckwith. *Am. Water Works Assn.—Jl.*, vol. 23, no. 8, Aug. 1931, pp. 1120-1127. Characteristics of inadequate installations; rapid method of checking pump efficiency; table of gallons of water delivered per kw-hr. against various heads on assumption that pump and motor are 100 per cent efficient; results of checking efficiency; measuring output of water.

Electrolysis

The Preparation of Organic Compounds by Electrolytic Methods—IV, S. Glasstone. *Indus. Chemist*, vol. 7, no. 79, Aug. 1931, pp. 315-317. Chemical and electrochemical halogenation; electrochemical chlorination; manufacture of bromoform and iodoform; chloroform and chlorhydrin; electrochemical diazotization.

Engineers

SALARIES. Relation Between an Engineering Education and Income, J. D. Beatty. *Indus. and Eng. Chem.*, vol. 23, no. 9, Sept. 1931, pp. 1070-1074, 6 figs. How salaries of engineers compare with salaries of men in other professions; what groups in engineering profession receive best salaries; how salaries of engineering graduates of Carnegie Institute of Technology compare with salaries of graduates from other engineering institutions generally.

Frequency

STANDARDIZATION. Frequency Standardisation. *Engineer*, vol. 152, no. 3941, July 24, 1931, p. 96. When general interconnection was deemed to be desirable, problem of frequency standardization presented itself, but it remains to be seen whether widespread interconnection will prove great boon; on frequency standardization alone very large amount of money is being spent.

Furnaces

ANNEALING. Applications of the Electric Furnace for Non-Ferrous Metals With Special Reference to the Bright Annealing Process, H. C. Kloninger, G. Keller and H. Meuche. *Inst. Metals—Advance Paper*, no. 575, for mtg. Sept. 14-15, 1931, 18 pp., 12 figs. Main types of furnaces used for bright-annealing process; during past few years considerable improvements have been made in quality of product as well as in simplifying handling of annealed metals.

ARC. Twenty Year Advance in Electric Arc Furnaces for the Production of Iron and Steel, W. E. Moore. *Electrochem. Soc.—Preprint*, no. 60-11, for mtg. Sept. 2-5, 1931, pp. 65-78. In period of two decades electric arc melting furnace has made wonderful progress, having increased in number 65 times, in maximum size per heat five times, in maximum daily capacity 10 times, and power consumption per unit ton output has been decreased from 600-800 to 400-600 kw-hr.; carbon electrode consumption decreased from 30-40 lb. (14-18 kg.) down to 8-15 lb. (3.6-6.8 kg.).

ELECTRODES. The Soderberg Electrode, Oblong Electrodes and Other New Developments, M. Sem. *Electrochem. Soc.—Preprint*, no. 60-20, for mtg. Sept. 2-5, 1931, pp. 199-210, 4 figs. Electric furnace engineers originally objected to round cross section Soderberg electrode; they were convinced that oblong or rectangular electrodes were essential for efficient furnace operation; oblong electrodes produce larger active hearth, and gases evolved during furnace operation are more evenly distributed through charge; however, round electrodes are often to be preferred on account of certain electrical features and advantages.

HEAT TREATING. Electricity Used on a Large Scale for Heat Treating, G. Coley. *Iron Age*, vol. 128, no. 12, Sept. 17, 1931, pp. 747-751, 8 figs. Description of heat-treating furnaces; pig iron from blast furnaces and cupolas is duplexed with electric furnaces for making iron castings, at plant of Ford Motor Co.

INDUCTION. Tonnage Melting by Coreless Induction—VI, E. F. Northrup. *Fuels and Furnaces*, vol. 9, no. 9, Sept. 1931, pp. 1067-1071, 1 fig. Various classifications under which coreless induction melting may be considered; use of coreless induction furnace as refining furnace and ladle; future of industrial melting.

INDUSTRIAL. Heat Treating, Forging and Melting with Electricity, G. Coley. *Iron Age*, vol. 128, no. 11, Sept. 10, 1931, pp. 678-683 and 721, 12 figs. Equipment and procedure at plant of Ford Motor Co. with connected load of 85,000 kw., electric furnaces for duplexing blast-furnace and cupola iron in foundry, and indirect arc furnaces in brass foundry.

Fuses

ELECTRIC. Fuse Performance in Relay Service, H. D. Braley. *Power*, vol. 74, no. 6, Aug. 11, 1931, pp. 200-201. Test results show how accurate fuses of same size are in time of interrupting overload, how sensitive they are to load changes, and how selective two or more fuses, of different sizes in series, are in clearing fault on power systems.

Gases

CONDUCTIVITY. The Conductivity of Gases in Uniform Electric Fields, S. P. McCallum. *Lond. Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 76, Aug. 1931, pp. 384-392. In many recent publications various theories of electrical discharge have been elaborated which are based on hypotheses of doubtful validity; attention is drawn to objections that have already been raised to these theories, and results are compared with results of experiments on monatomic gases which have recently been made at Electrical Laboratory, Oxford.

Generators

GROUNDING. The Effects on Noise Induction of Grounded Neutral Generators. *Nat. Elec. Light Assn.—Pub.*, no. 153, Aug. 1931, 4 pp. Results of investigations of effects on noise frequency induction of grounded neutral generators feeding directly on line; nature and source of difficulties experienced are explained and several possible remedial measures are described.

Grid Glow Tube

CONTROL. Application of the Grid-Glow Tube to Oil Burner Control, J. P. Kriechbaum, J. V. Breisky and T. Draper. *Oil Heat*, vol. 4, no. 9, Sept. 1931, pp. 11-12 and 66, 2 figs. Design, construction and operating features of Protecto Glow System; oil burner safety devices.

Harmonics

MEASUREMENTS. Measuring Voltage Harmonics, E. Heuter. *Elec. Rev.*, vol. 109, no. 2804, Aug. 21, 1931, pp. 280-281, 4 figs. Instrument described depends on simple application of resonance principle and enables magnitude of voltage harmonics to be measured directly.

Heating

GREENHOUSES. Electrically Heated Greenhouse, G. N. Hawley. *Elec. World*, vol. 98, no. 8, Aug. 22, 1931, pp. 322-323, 2 figs. Electric heating of greenhouse at Riverside, Calif., has proved so successful that another new and profitable field for industrial heating has been opened to power company and nurserymen are able to make 75 per cent saving in investment for heating equipment.

RAILROAD SHOPS. Railroad Saves Six Times Electric Heat Cost, W. S. Scott. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 423-427, 3 figs. Study was made of major heat-treating operations in repair shops of Norfolk & Western Railway, and figures arrived at, and agreed upon, as conservatively representing annual savings by virtue of electric heating; power cost $17,805 in one year and savings credited to its use in electric heat amount to more than $100,000.

Hydroelectric Plants

AUTOMATIC. The Upper Notch Automatic Hydro-Electric Power Plant, R. F. Legget, P. J. Croft, J. R. Desloover. *Eng. Jl.*, vol. 14, no. 8, Aug. 1931, pp. 437-444, 12 figs. Plant located on Montreal river, 15 mi. southeast of Cobalt, northern Ontario; equipment consists of two 48-ft. head, 6,500-hp. 125-r. p. m. turbines, and two 6,500-kva., 11,000-volt, 25-cycle generators; switchgear and control equipment are fully automatic and are designed for possible remote control from distant point; switchgear is of metal clad type; station output transformed to 110,000 volts by three 4,500-kva. transformers and is fed into extensive network by means of line 32.7 mi. long.

INTAKES. Recent Applications of Draft Distributors to Power Plant Intakes, H. G. Acres. *Eng. News-Rec.*, vol. 107, no. 11, Sept. 10, 1931, pp. 403-410, 13 figs. Rational design of intakes long neglected; studies made for Queenston-Chippawa plant in Canada led to development of Johnson-Wahlman draft distributor; four intakes designed to meet diverse conditions; elements of ideal intake design; intake of Chelan development of Washington Water Power Co. of Spokane; 14 ft. and 17 ft. in diam.; intake for St. John River Power Co. at Grand Falls, New Brunswick; delivers 7,500 sec. ft.; design of intake for projected development of 10,000- to 12,000-sec. ft. capacity.

Illuminating Engineering

RUSSIA. Progress in Illuminating Engineering in the U. S. S. R., Slokhay-Natalchenko. *Illum. Engr.*, vol. 24, Sept. 1931, pp. 220-222, 4 figs. During period 1921-30 illuminating engineering has made great progress in U.S.S.R.; vital part played by illumination is now recognized fact; good lighting is regarded as important in all branches in industry, and especially as means of improving safety and health; there are quite a number of laboratories interested in illumination in Leningrad, Kharkov, Moscow and other cities; notes on Illumination Congress of U.S.S.R.

Industrial Plants

ELECTRIC CONTROL. Centralized Control for Aggregate Plant, L. F. Leurey. *Elec. West.*, vol. 67, no. 3, Sept. 1, 1931, pp. 120-123, 8 figs. Electric operation of modern sand and gravel plant of Kaiser Paving Co., Pleasonton, Calif.; raises operating efficiency through reducing starting time and labor costs.

ELECTRIC POWER. Distributing the Electric Energy, R. G. Hornberger. *Maintenance Eng.*, vol. 89, no. 8, Aug. 1931, pp. 381-384, 3 figs. Review of design fundamentals of distribution system in industrial plant; typical wiring layouts.

Industrial Electrification—I and II, R. H. Wilmot. *Elecn.*, vol. 107, nos. 2775 and 2777, Aug. 7, 1931, pp. 186-189 and Aug. 21, pp. 247-249, 6 figs. Numerous advantages of electrical drive; use of a-c. or d-c. supply; private power generation or public power supply; mechanical *vs.* electrical drive; comparison of costs is given in numerical examples.

Insulating Materials

PORCELAIN. Mechanical and Thermal Shock Tests on Cermic Insulating Materials, H. M. Kraner and R. A. Snyder. *Am. Ceramic Soc.—Jl.*, vol. 14, no. 9, Sept. 1931, pp. 617-623, 3 figs. Simple tests, as developed for daily production of electrical porcelain; laboratory tests and results for number of ceramic insulating materials; from these it is shown that mechanical strength and resistance to thermal shock are valuable indications of mechanical properties of bodies and glazes; results obtained in testing foreign and American-made porcelains are compared.

The Effect of Firing Temperature on the Dielectric Strength of Porcelain, A. J. Monack and L. R. Shardlow. *Am. Ceramic Soc.—Jl.*, vol. 14, no. 9, Sept. 1931, pp. 603-607, 5 figs. Electrical porcelain body was fired to various cone temperatures and puncture voltages were determined; data from tests in which number of specimens used was sufficiently large to give mean values with small probable errors.

Insulating Oil

Report of Insulating Oils. *Int. Electrotech. Commission—Report of mtg. Advisory Committee*, no. 10, Stockholm, June-July, 1930. Documents from Canada, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Switzerland, Sweden, and United States, in their respective languages.

Insulators

TESTING MACHINES. Testing Machine for Insulators. *Engineering*, vol. 132, no. 3420, July 31, 1931, pp. 130-132, 7 figs. Testing machine, installed in high-tension laboratory of General Electric Co., enables insulators to be subjected to longitudinal and transverse stresses while exposed to electric pressure; made by W. and T. Avery; it is suitable for testing insulators of either post or string types, and can be used for tension or torsion tests, or for combination of two, and also for combined tension and vibratory test, up to maximum load of 24,000 lb

Lamps

GLOW. Gaseous Discharge Tubes. *Elecn.*, vol. 107, no. 2778, Aug. 28, 1931, pp. 273-275, 8 figs. Ripple neon; possibilities of hot cathode lamp; neon tubes as plant stimulant; actual photographs of various forms of blue ripple discharge; photographs of neon ripple and striated discharge; hot cathode lamp circuit for single phase a-c. supplies; and for three-phase supplies; characteristic of hot cathode tube.

Light and Lighting

Brightness Contrasts Determine Visual Efficiency, M. Luckiesh. *Elec. World*, vol. 98, no. 7, Aug. 15, 1931, p. 280. Although it is impractical to present complete table of brightness contrasts encountered in seeing, number of typical examples which have wide application have been selected for purpose of illustration, are given.

STREET. The Evaluation of Glare in Street-Lighting Installations, W. S. Stiles. *Illum. Eng.*, vol. 24, Aug. 1931, pp. 187-189, 4 figs. Maximum permissible glare; glare curves of center suspension and staggered suspension systems; elimination of glare from distant lamps; methods of calculation elucidated in appendix. (Concluded.)

Lightning Protection

SIGNALS AND SIGNALING. Lightning on Signal Power Lines, C. L. Jones. *Ry. Signaling*, vol. 24, no. 8, Aug. 1931, pp. 276-279, 4 figs. Results of certain field and laboratory analyses of lightning disturbances on signal power transmission lines; wiring diagram of signal power circuit. Bibliography.

Loud Speakers

Means for Radiating Large Amounts of Low Frequency Sound, E. W. Kellogg. *Acoustical Soc. Am.—Jl.*, vol. 3, no. 1, pt. 1, July 1931, pp. 94-110, 3 figs. Principals and possibilities of electroacoustic device of large radiating power are discussed; consideration of possible types of loud speaker with large area single diaphragm with baffle; large area composed of multiple units, with baffle; multi unit, short horn construction; long horn type, one or several unit; siren type with horn.

Magnetic Alloys

PROPERTIES. Some Magnetic Alloys and their Properties, H. H. Potter. *Lond. Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 76, Aug. 1931, pp. 255-264, 4 figs. One of most striking physical properties of element manganese is its tendency to form in conjunction with other non-ferro-

magnetic elements binary and ternary alloys which show pronounced ferro-magnetism; complete analysis of magnetic properties of binary and ternary alloys conveying manganese is given.

Magnetic Hardening

METALS. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. *Metallurgia*, vol. 4, no. 20, June 1931, pp. 47-50, 10 figs. Precession theory of hardening; graphs illustrating results of experimental work, leading to new conception of philosphy of hardening, including quench-hardening, work-hardening, age-hardening, and hardening of work-hardened metals by low-temperature annealing.* Bibliography.

Measurements

Precision Measurements of Alternating Currents Up to 2,000 Amperes, A. H. M. Arnold. *Jl. Sci. Instruments*, vol. 8, no. 5, May 1931, pp. 154-155. Figures are given of performance of current transformer with nickel iron core, having ratio 2,000/1, operating on burden of 100 volt-amperes at rated current; ratio is within 3 parts in 10,000 of its nominal value in frequency range 25 cycles per sec. to 100 cycles per sec. at full current to one-tenth of full current; in conjunction with non-inductive resistance of accurately known value and electrostatic voltmeter, transformer may be used for measuring currents up to 2,000 amperes with accuracy of few parts in 10,000.

Measuring Instruments

SPECIFICATIONS. Report on Electrical Measurement Instruments. *Int. Electrotech. Commission—Report of mtg. Advisory Committee*, no. 13, Stockholm, June-July 1930. Documents from Argentina, Germany, Italy and United States in their respective languages.

Mica

ELECTRIC PROPERTIES. Some Electrical Properties of Foreign and Domestic Micas and the Effect of Elevated Temperatures on Micas, A. B. Lewis, E. L. Hall and F. R. Caldwell. *U. S. Bur. Standards—Jl. Research*, vol. 7, no. 2, Aug. 1931, pp. 403-418, 8 figs. Number of samples of mica, fairly representable of major sources of world's supply, were tested for dielectric constant, power factor, dielectric strength, and ability to withstand elevated temperatures; results.

Motors

ALTERNATING CURRENT. A-C. Commutator Motors. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, pp. 323-324, 7 figs. Widespread adoption of a-c. has resulted in paying of increased attention to variable-speed a-c. three-phase motors; shunt performance curves of motor with series characteristics are given.

ENCLOSED. Enclosed Electric Motors. *Engineer*, vol. 152, no. 3943, Aug. 7, 1931, p. 152, 4 figs. Motors designed by Lancashire-Dynamo Motor Co., Trafford Park, Manchester, to meet adverse conditions; one of them is totally enclosed machine primarily designed for gas works; other is totally enclosed frame-cooled machine, known as "Tefeo" motor; it is standard Lancashire squirrel-cage or slip-ring machine, fitted with internal end shields and special end covers.

FRACTIONAL HORSEPOWER. Voltage Relations and Losses in Small Universal Motors, A. F. Puchstein and I. S. Campbell. *Ohio State Univ. Studies—Eng. Experiment Station—Bul.*, no. 58, Jan. 1931, 27 pp., 24 figs. Importance of data on universal motors; general test results and conclusions; apparatus arrangement and test methods used; determination of losses; voltage-vector test data and results; motor-loss test data and results. Bibliography.

SPEED REGULATION. Speed Regulation of Alternating-Current Motors, G. W. Stubbings. *Mech. World*, vol. 90, no. 2330, Aug. 28, 1931, pp. 196-198, 2 figs. Three principal methods of speed control discussed are pole changing, rheostatic control of rotor resistance, and use of commutator.

SYNCHRONOUS. New Synchronous Motor for High-Torque Loads, R. S. Wright. *Elec. World*, vol. 98, no. 8, Aug. 22, 1931, pp. 320-322, 6 figs. Design engineers worked for several years to perfect motor having desirable running characteristics of standard synchronous motor yet capable of developing high starting and pull-in torque with low starting current; result of these investigations has been development of new low-speed (450 r. p. m. and below) motor which has mechanical simplicity and is highly efficient.

Networks

FAULT RECORDERS. Der Siemens-Stoerungschreiber (Siemens' System Disturbance Recorder), W. Hofmann and P. M. Pflier, *Siemens Zeit.*, vol. 11, no. 7, July 1931, pp. 325-333, 12 figs. Analytical review of various types and their characteristics; new three-phase automatic recorder of Siemens' and Schuckert, and its testing; test data are given in curves and tables.

PROTECTION. Relay Study for the Application of Impedance Relays to Ground Fault Protection, L. S. C. Tippett. *Instn. Engrs. Australia—Jl.*, vol. 3, no. 7, July 1931, pp. 233-243, 16 figs. Method of applying theory of symmetrical components to analysis of performance of impedance relays of conventional design when used for protection against ground faults; as preliminary to this method of determining correct impedance networks of any given system is discussed, under various operating conditions; application is made to portion of Victorian State Electricity Commission's system which gives ample illustration of principles involved.

Photoelectric Cells

Recent Contributions to Light Valve Technic, O. O. Ceccarini. *Soc. Motion Picture Engrs.—Jl.*, vol. 17, no. 3, Sept. 1931, pp. 305-320 and (discussion) 320-325, 15 figs. Structural changes made in light valves with object of improving their quality, stability of operation, and efficiency, most important being introduction of damping to off-set resonance; these features are chiefly considered from standpoint of production requirements and engineering economies; new synchronous slit type oscillograph permitting study of behavior of valve is described.

Ionization in Gas-filled Photoelectric Cells: The Inert Gases in Coesium on Silver Photoelectric Cells, and Time Lag in Gas-filled Photoelectric Cells, W. F. Tedham. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, vol. 12, no. 76, Aug. 1931, pp. 224-232, 8 figs. Some uncertainty appears to exist as to best gas-filling in use in photoelectric cells which are sensitive to visible or infra-red light; in view of this uncertainty, question of relative advantages of helium, neon, and argon, and also krypton and xenon as gas-fillings in photoelectric cells were reinvestigated in some experiments.

Power Factor

IMPROVEMENT. The Correction of Low Power Factor, J. Leech-Porter. *Can. Min. Jl.*, vol. 52, no. 24, July 1931, pp. 616-618, 3 figs. Various methods for improvement of power factor conditions in industrial plants using induction motors for drive; methods for calculating returns, *i. e.*, first cost; operating costs; gross returns; net returns; points to investigate; application of methods shown for case of motorcycle company employing 104 motors ranging from 1 to 150 hp. with total rating of 1,850 hp.

Power Industry

GOVERNMENT CONTROL. Socialization or Private Enterprise, W. H. Onken, Jr. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 110-111. In reality, experience proves that notwithstanding all advantages possessed by governmental undertaking, private enterprise, in this case electric light and power corporation, more often than not renders better service at less cost; this is due to two outstanding and very obvious disadvantages of governmental enterprises, *i. e.*, political interference in operation of project and lack of incentive.

RATE MAKING. Regulation by Conference Versus Formal Rate Proceedings, L. O. Whitsell. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 108-110. Author brings to bear six years of experience in regulation by proposing that informality replace formality in rate matters and that utilities take voluntary action which will make them largely self-regulating. Before Pac. Coast Elec. Assn.

UNITED STATES. The Electric Light and Power Industry, Basic Statistical Data. *Nat. Elec. Light Assn.—Statistical Bul.*, Aug. 1931, 39 pp. Statistics contained in report embrace operations of enterprises devoted exclusively to generation and distribution of electricity, plus electric departments of all others which maintained electric light and power systems jointly with other public utility services; data were determined from reports received at N. E. L. A. headquarters from some 400 companies, whose operations represented approximately 92 per cent of entire industry.

Power Supply

SERVICE INTERRUPTION. Service Interruption for Repairs Should be Announced, H. A. Martin. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, p. 367. When extensive prearranged interruptions are necessary over period of several days, notice should be placed in newspaper in town being served that service will be interrupted and this notice should state why interruption is necessary and give definite schedule of hours and dates during which no service may be expected.

Radio

MEASURING INSTRUMENTS. Use of Automatic Recording Equipment in Radio Transmission Research, P. A. de Mars, G. W. Kenrick and G. W. Pickard. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 9, Sept. 1931, pp. 1618-1633, 10 figs. Apparatus developed for low-frequency (17.8 kc.), intermediate-frequency (770 kc.), and high-frequency (6942.5 kc.) field-intensity recording; circuits employed are discussed with particular reference to expedients for obtaining nearly logarithmic scales when used with Leeds and Northrup recording potentiometer.

RECEIVING APPARATUS — NOISES. Noise Generation Within Radio Receivers, R. de Cola. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 15-17, 7 figs. Theoretical discussion of radio receiver design as related to employment of new type tubes; noises resuming from thermal agitation; shot effect; and secondary emission and ionization; thermal agitation. Before Inst. Radio Engrs.

Railroads

ELECTRIC CONTROL. La régulation par unités multiples et l'automatisme dans la marche des motrices électriques (Multiple Control and Automatic Control in Operation of Electric Driven Vehicles), L. Barbillion. *Technique Moderne*, vol. 23, no. 15, Aug. 1, 1931, pp. 517-524, 13 figs. Fundamental principles, diagram showing automatic control by reversing controller system Sprague; control by contactors of powerful modern units; Thomson Houston system; electropneumatic control of Westinghouse; use of camshaft; Sprague Thomson system as used on Paris subway with wiring diagram; Jeumont-Heidman system on same railroad.

SUBSTATIONS. Heavy-Duty Rectifiers and Their Application to Traction Substation, J. W. Rissik and H. Rissik. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 933-963 and (discussion) 963-982, 23 figs. As result of special problem associated with supply of d-c. to traction systems, as distinct from lighting and power systems, automatic substations technique has advanced in two widely diverging directions; whereas modern substation practise in America is characterized by almost exclusive use made of rotary convertors, European practise favors adoption of mercury-arc rectifiers; present state of development of iron-clad rectifier and its application to traction supply as reflected in more recent converting installations on Continent.

Crawler Cranes Solve Problem in Railroad Electrification, T. J. Skillman. *Elec. World*, vol. 98, no. 9, Aug. 29, 1931, p. 371, 1 fig. Erection of steel for substation, tower and miscellaneous purposes in railroad electrification work sometimes proves difficult for structures not sufficiently close to main railroad tracks to permit handling by locomotive crane; here crawler cranes have proved their value in convenience and economies.

Rating

ELECTRIC MACHINERY. Report on Rating. *Int. Electrotech. Commission—Report of mtg. of Advisory Committee*, no. 2, Stockholm, June-July, 1930. Documents from Austria, France, Germany, Japan, Poland, Sweden, Switzerland, and United States, in their respective languages.

Reactive Power

METERING. Reactive Kva. Metering—IX, E. C. Goodale. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 116-117, 5 figs. Two-element three-phase meters do not give accurate results on four-wire circuits under normal conditions.

Reactors

Design of Standards of Inductance, and the Proposed Use of Model Reactors in the Design of Air-Core and Iron-Core Reactors, H. B. Brooks. *U. S. Bur. Standards—Jl. Research*, vol. 7, no. 2, Aug. 1931, pp. 289-328, 10 figs. Useful general relations concerning self and mutual inductance of geometrically similar coils are presented and their usefulness is demonstrated.

Rectifiers

COPPER OXIDE. Metal Rectifier Applications. *Engineer*, vol. 152, no. 3947, Sept. 4, 1931, pp. 241-243, 15 figs. Best-known applications are those associated with wireless reception; but this simple method of rectification is applicable in many other directions, and currents and voltages considerably greater than those heeded for wireless reception can be dealt with.

Regulators

INDUCTION. The Application of Induction Regulators, V. C. Bryan. *Elec. Rev.*, vol. 109, no. 2805, Aug. 28, 1931, p. 316, 4 figs. Fundamental principles of apparatus which is not so generally understood, either in theory or in application.

Remote Control

POWER PLANTS. Remote-Control Switchgear at Woolwich. *Engineer*, vol. 152, no. 3940, July 17, 1931, p. 76, 3 figs. Installation of remote electrically controlled switchgear put into service at Bellwater Gate power station of Woolwich Borough Council; switchgear is designed for pressure of 6,600 volts and is electrically operated by remote control from corresponding panels on main control board situated in central position in station; cubicles are built up of molded stonework slabs reinforced by steelwork.

SIGNALS AND SIGNALING. Chicago Great Western Saves $7,000 Annually by Remote Control of Tunnel Interlockings. *Ry. Age*, vol. 90, no. 22, May 30, 1931, pp. 1071-1072, 3 figs. Increased safety and flexibility of operation, and high return on investment have amply warranted expenditure of $18,000; solution of problem; operation of system; color light signals and dual control switch machines; economies effected.

Resistors

DESIGN. The Design and Construction of a Shielded Resistor for High Voltages, R. Davis. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 416, Aug. 1931, pp. 1028-1035, 2 figs. Design of shielded resistor for use at voltages up to 60 kv.; considerations governing design are discussed in detail; construction and performance of resistor are dealt with and finally question of extending further range of such apparatus is touched upon.

Rotors

Dead Points in Old Rotors, W. L. Hurlburt. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, p. 123, 1 fig. When modernizing control equipment of some old wound-rotor induction motors equipped with slip rings and external starting resistance, dead points often develop at start if resistance is removed; leakage flux conditions should be observed.

TURBO-GENERATORS. Stresses in Retaining and Centering Rings for Turbine-Generator Rotors, R. Patterson and D. H. Harms. *Applied Mechanics* (*A.S.M.E. Trans.*) vol. 53, no. 9, May-Aug. 1931, pp. 79-87 and (discussion) 87-89, 10 figs. Paper before Am. Soc. Mech. Engrs., indexed Engineering Index 1930, p. 1829, from Advance Paper, no. 42, for mtg. Dec. 1-6, 1930.

Switchgear

STANDARDIZATION. A Discussion of New Standards for Switching Equipment and Insulator Units as Adopted by N.E.M.A. *Elec. Light and Power*, vol. 9, no. 9, Sept. 1931, pp. 27-29, 2 figs. Rated voltage; determination of flashover values corresponding to preferred voltage ratings; curve showing minimum wet and dry flashover values for assembled, upright, base-mounted insulators; correction factors for apparatus rated on basis of varying altitudes; theoretical minimum safe distances to ground for various voltages at 60 cycles; spacing of insulator columns for various voltages.

Telephone Relays

Characteristics of Strowger Relays, R. W. Graybill. *Telephone Engr.*, vol. 35, no. 8, Aug. 1931, pp. 25 and 28, 5 figs. Discussion of features of horizontal relay structure which may be varied to secure different performance characteristics and which account for long life of this type of relay.

Television

Television, E. H. Felix. N. Y., McGraw-Hill Book Co., 1931, 272 pp., illus., diagrs., charts, $2.50. Book explains basic processes involved in any television system and describes methods of existing systems; standards of performance requisite to commercial service are outlined, and limitations of existing methods are pointed out; gives good general survey, in not too technical language, of present situation, problems that television faces, and its probable future. Eng. Soc. Lib., N. Y.

RECEIVING APPARATUS. Standards of Performance for Commercial Television Receivers, C. H. W. Nason. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 30 and 45, 2 figs. Television receiver design as distinguished from radio sound receiver design; typical selectivity curve; sensitivity characteristics and fidelity curves for television receiver.

DESIGN. The Design of a Complete Television System, C. E. Huffman. *Radio Eng.*, vol. 11, no. 8, Aug. 1931, pp. 36 and 38, 10 figs. Technical information of direct use to radio engineers who desire to master elements of television. Before Radio Club.

Testing Laboratories

MANUFACTURING PLANTS. Baltimore's High Voltage Laboratory, D. H. Rowland. *Baltimore Engr.*, vol. 6, no. 5, Aug. 1931, pp. 9-11 and 16, 6 figs. High voltage laboratory of Locke Insulator Corp., makes available to electrical industry facilities which are of greatest importance in considering future growth of electrical transmission; laboratory is capable of producing 2,500,000 volts; equipment is briefly described. Before Am. Inst. Elec. Engrs.

Transformers

OSCILLATIONS. Transformer Oscillations Caused by Damped Oscillatory Waves, L. V. Bewley. *Gen. Elec. Rev.*, vol. 34, no. 9, Sept. 1931, pp. 512-517, 8 figs. Purpose of article is to consider possibilities of building up excessive internal oscillations in transformers by means of damped oscillatory incident waves, and in particular to show effects of transformer losses and decrement of applied wave in limiting these abnormal internal voltages.

Transmission Lines

DESIGN. On the Determination of Stringing Tensions for Transmission Lines and Cables, J. W. Campbell. *Eng. Jl.*, vol. 14, no. 9, Sept. 1931, pp. 477-481. Method for finding temperature-tension relations for suspended cables; of single spans with points of support at same level, single spans with points of support at different levels, composite spans which have intermediate supporting structures; hyperbolic methods are used throughout, validity of method for sage of any magnitude is shown.

HIGH TENSION. The Louisville-Cincinnati Interconnection, H. W. Eales. *Elec. Light and Power*, vol. 9, no. 9, Sept. 1931, pp. 30-34, 13 figs. Since Oct. 16, 1930, 32,000 kw. of power were transmitted from Columbus, Ohio, steam plant of Cincinnati system to Louisville over new 82-mi., 138,000-volt transmission line; principal features of interconnection; map showing course of line is given.

LIGHTNING PROTECTION. Slow Cloud Ionization Confirms Direct-Stroke Theory, C. L. Fortescue. *Elec. World*, vol. 98, no. 10, Sept. 5, 1931, pp. 420-421. Field experiences have given firm support to theory that direct stroke rather than induced stroke is cause of transmission outrages due to lightning; discharge time precludes induced voltage; one of primary requisites of ground wire protection therefore is that ground wire shall always interpose itself as shield against oncoming strokes. Before Am. Inst. Elec. Engrs.

VIBRATIONS. Dampers Installed on "Hot" 110-Kv. Line, P. J. Ost. *Elec. West*, vol. 67, no. 3, Sept. 1, 1931, pp. 114-115, 1 fig. Electrical department of City of San Francisco will install some 10,600 vibration dampers on its Hetch Hetchy transmission line; this line is of double-circuit, steel-tower construction carrying two 110-kv. circuits of 397,500 cir. mil A.S.C.R. conductors suspended from ten-unit insulators; equipment is described.

Vacuum Tubes

The Variation of the Resistances and Interelectrode Capacities of Thermionic Valves with Frequency, L. Hartshorn. *Experimental Wireless*, vol. 8, no. 95, Aug. 1931, pp. 413-421, 5 figs. Nature of changes and their order of magnitude are considered and estimation of errors arising from usual assumptions will be possible in any given case.

DETECTOR. A Method of Calculating the Performance of Vacuum-Tube Circuits Used for the Plate Detection of Radio Signals, J. P. Woods. *Univer. Texas—Bul.*, no. 3114, Apr. 8, 1931, 71 pp., 21 figs. Complete mathematical analysis pertaining to standard signal; detection of small signals; ideal detection; limited theory of large signal detection; extension to include pure resistance loading in grid and plate circuits; power series analysis of static characteristic; analysis of detection performance of UX-201A vacuum tube. Bibliography.

HOT CATHODE. A Method of Determining the Impedance of Hot Cathode Discharge Tubes, W. F. Westendorp. *Rev. Sci. Instruments*, vol. 2, no. 8, Aug. 1931, pp. 437-446, 8 figs. By means of superposed alternating current negative resistance of hot cathode neon and mercury direct current arcs was measured and found to follow closely slope of static characteristic of neon arc and to be widely different in case of mercury arc; at same time reactance for ripple current in arc was determined.

THYRATRON. Some Characteristics of Thyratrons, J. C. Warner. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 9, Sept. 1931, pp. 1561-1568, 6 figs. Fundamental characteristics; comparison with characteristics of high-vacuum tubes to show outstanding advantages and limitations; starting characteristics; typical examples; several types of thyratrons described.

Watthour Meters

INDUCTION. The Induction Watt Hour Meter, J. L. Ferns. *Elec. Times*, vol. 80, no. 2078, Aug. 20, 1931, pp. 275-277, 5 figs. Methods of producing phase difference for friction compensation; prevention of creep; quadrature adjustment; driving torque; brake torque; temperature variations; voltage variations; frequency variations; wave form variations.

Welding

LOCOMOTIVE FRAMES. Arc Welding of Locomotive Frames—I and II, J. M. Vossler. *Welding*, vol. 2, no. 8, Aug. 1931, pp. 511-513, 7 figs. Method of filling in vees, proper selection of electrodes and relieving of strains by heat treatment are important factors in securing sound weld.

PIPE. Welding Brass and Copper Piping, D. W. Endicott. *Am. Welding Soc.—Jl.*, vol. 10, no. 7, July 1931, pp. 26-29, 6 figs. Advantages of welding construction; investigation by Linde Air Products Co., to determine most desirable type of design for joints in copper and brass tubing, best welding procedure, most suitable welding rod, weldability of joints in various positions, and relative strength of various joint designs.

JOINTS. Pipe Welding—How, When and Where to do it—III, W. Spraragen. *Welding*, vol. 2, no. 7, July 1931, pp. 450-454, 7 figs. Application of welding; fabrication of large 82-in. receiver pipe for Westinghouse cross-compound steam turbine; comparative cost of header construction; graphic representation of stress transfer in collar and vee-type joints; manufacture of pipe by automatic carbon arc process.

STEEL STRUCTURES. Structural Arc Welding Progress, A. F. Davis. *Welding Engr.*, vol. 16, no. 8, Aug. 1931, pp. 42-46, 10 figs. Paper before West. Metal Congress, previously indexed from Metal Progress, Feb. 1931.

STRUCTURAL STEEL. Welding of Structural Steel, J. Ferguson. *Am. Welding Soc.—Jl.*, vol. 10, no. 7, July 1931, pp. 39-43, 12 figs. Enumeration of 10 advantages of welding; means of which welding may be advanced; factors affecting proper fabrication of welded steel. Before Am. Welding Soc.

Welds

ANALYSIS. Dissolved Nitrogen Embrittles Weld Metal, F. R. Hensel and E. I. Larsen. *Metal Progress*, vol. 20, no. 3, Sept. 1931, pp. 44-47, 5 figs. Investigation of effect of nitrogen on properties of welds at Westinghouse Research Laboratories; analyses of welded pads; to improve arc welds materially nitrogen must be reduced below 0.05 per cent; micros showing dispersion hardening of iron nitride.

STRENGTH. The Strength of Frontal and Lateral Welds, E. Hoehn. *Engineering*, vol. 132, no. 3419, July 24, 1931, pp. 115-118, 22 figs. Lap welds may be frontal or lateral; term lateral denotes weld which runs parallel to line of action of resultant load on weld, while in frontal weld fillet stands square to resultant force; test results show that specific resistance diminishes as height of fillet increases; causes of decrease in resistance of frontal welds to tearing are explained, and empirical rule found for its variation with height of fillet. Translated from report to Swiss Boiler Owners' Assn.

Industrial Notes

220,000 Volt Transmission Line Across the Susquehanna.—The work of carrying the transmission line from the Safe Harbor hydroelectric development across the Susquehanna River is now being completed. The crossing, which is over two railroads and a mile stretch of river, is between hills some 300 feet high. There are two spans of 3,000 feet each between a tower on an island near the middle of the river and those on the high hills on either side. In all, ten cables of aluminum-steel are to cross the river. The cables will carry power over a 70 mile, 220,000 volt transmission line to the system of the Consolidated Gas, Electric Light and Power Company of Baltimore. Safe Harbor will also be interconnected with the power development of the Pennsylvania Water & Power Company at Holtwood on the Susquehanna River.

Insulators for Pennsylvania Electrification.—A large order for porcelain insulators has been placed by the Pennsylvania Railroad with the Westinghouse Electric & Manufacturing Company. These insulators will be used in the new electrification now being continued toward Washington from Wilmington. If shipped at one time this order would make a freight train of 82 cars of 30,000 pounds capacity each. According to the Westinghouse Company, the transmission system for which these insulators are ordered exceeds in magnitude any previous undertaking for railroad operation in the world and uses 132,000 volts to carry the current to the various substations.

Power-Factor Correction Condensers for P. & L. E. R. R.—An order from the Pittsburgh & Lake Erie Railroad Co., for 45 units each of 4½ kva., 2,300-volt rating, has been received by the Dubilier Condenser Corporation, New York. The units are the standard Dubilier 5 kva. units, weighing 73½ pounds, and measuring 5 by 17 by 21 inches. They are to be installed at Colona, Pa., for power-factor improvement.

New High Voltage Rectifier.—What is claimed to be the largest continuous rating of dry, metallic rectifier for a given space is included in a new line of high voltage rectifiers announced by the B-L Electric Manufacturing Company, of St. Louis. Occupying a space of only 7¼ x 2¾ x 2¼ inches, this rectifier may be given a continuous output rating of 75 watts. It will operate directly from a 115 volt a-c. line.

Will Introduce New Fuse.—Dana Harland will direct the sales of the new "AE" fuse that is being introduced to the electrical industry by the Associated Engineers Company, of Chicago. The "AE" fuse is one of a long list of electrical improvements developed by the Associated Engineers Company, of Chicago, since its organization in 1908.

New Building for Jefferson Electric Company.—Announcement has been made that a contract for the construction of a new $550,000 plant has been awarded by the Jefferson Electric Company, of Chicago, to The Austin Company, engineers and builders, of Cleveland. The site is at the southwest corner of 25th Avenue and Madison Street, in Bellwood, and comprises approximately 19 acres of property. When the plant is completed on January 15, 1932, the company will abandon its present manufacturing units at 15th and Laflin Streets and Congress and Green Streets, Chicago. The Jefferson Electric Company was formed twenty years ago and merged five years ago with the Chicago Fuse Manufacturing Company.

New Time Switch.—A new Sauter, synchronous motor time switch is announced by R. W. Cramer & Company, Inc., 67 Irving Place, New York, the outstanding feature of which is a self-starting, slow speed synchronous motor. It is designed to operate at a certain speed in exact time with the frequency from the generating station, so that any number of these switches may be used to control multiple street lighting, sign and store window lighting, off-peak water heating and other time controlled circuits, all being turned on or off at the same time. It is equipped with laminated brush type copper contacts with silver arcing tips—quick make and quick break, and can be furnished in 2, 10, 15 and 25 ampere capacities for 110/220 volts, the synchronous motor being for use on 110 volts, 60 cycles.

Trade Literature

Contact Points.—Booklet, 24 pp., "Metallurgy and Design of Contact Points." Includes tables and diagrams illustrating the standard forms of contact points and fixtures available. Fansteel Products Company, Inc., North Chicago, Ill.

Insulated Cable.—Bulletin GEA 1312, 104 pp. Presents a compilation of information on all types of rubber insulated and miscellaneous insulated cable, including data on the selection of cable. General Electric Company, Schenectady, N. Y.

Fuses.—Booklet, 18 pp. The booklet gives a history of the invention and development of the fuse. It describes fuse construction and operation, as well as maintenance, and correct selection. Tables are included giving the sizes necessary for protection of motors and other appliances. Bussmann Manufacturing Company, University at Jefferson, St. Louis, Mo.

Wood Pole Specifications.—Bulletins. Contain the new American standard pole specifications for western red cedar, northern white cedar, creosoted yellow pine, and chestnut. In each case the specifications are tentative, but the dimensions are standard, and both were approved June, 1931. Inquiries should indicate which of the four specifications are of particular interest. Naugle Pole & Tie Company, 5 So. Wabash Avenue, Chicago, Illinois.

Thrust Bearings.—Bulletin HV, 40 pp. Describes vertical and horizontal thrust bearings whose parts are to a large extent interchangeable. Only standard, self-aligning, equalizing thrust bearings are covered therein. Capacities, weights and principal dimensions are given for the usual forms of these bearings. Kingsbury Machine Works, Inc., Frankford, Philadelphia, Pa.

Distortion Factor Meter.—Bulletin F-311, 4 pp. Describes type 536-A distortion factor meter for use in determining harmonic content of broadcasting station output, and to check through the amplifier in order to determine the source of distortion. The distortion factor is read directly on the dial, and the only operations required are those of throwing the switch and adjusting a potentiometer. General Radio Company, 30 State Street, Cambridge A, Mass.

Short-Center Drives.—Catalog, 148 pp., is described as an entirely new treatise of efficient short center drives compiled by the engineering staff of E. F. Houghton & Company. The book contains charts, tables and engineering data on 5,000 standard "Vim" efficiency drives ranging from 5 to 100 horsepower. A special mineral tanned leather belting is employed in these drives. The book was originally published for use by the company's field men, to assist them in discussing and working out transmission problems with engineers, and therefore it is not for general distribution. Copies will be delivered directly by a distributor to executives and engineers, interested in transmission drives, who will send in their requests in writing. E. F. Houghton & Company, Philadelphia, Pa.


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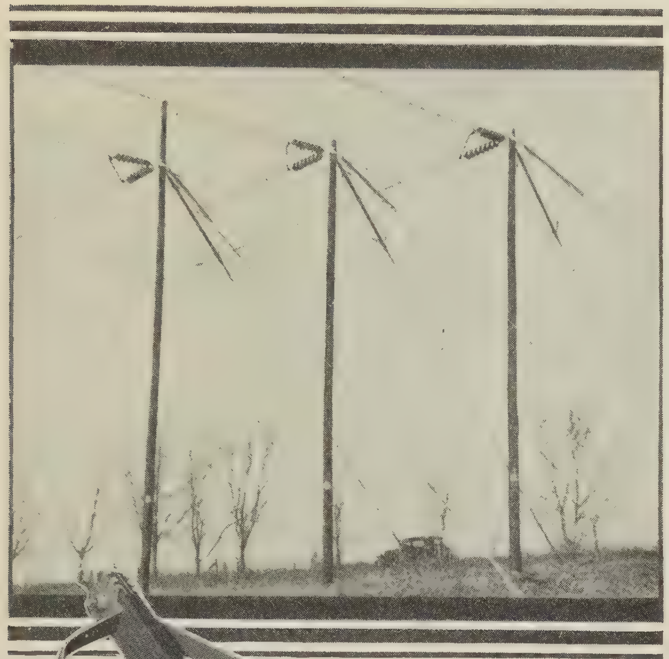

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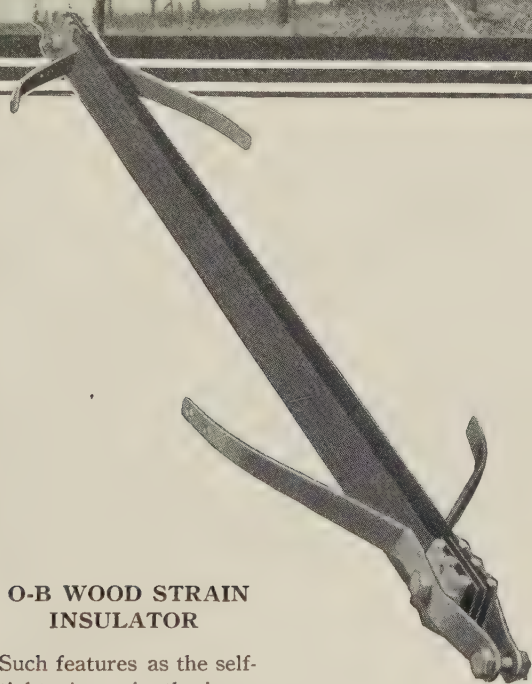

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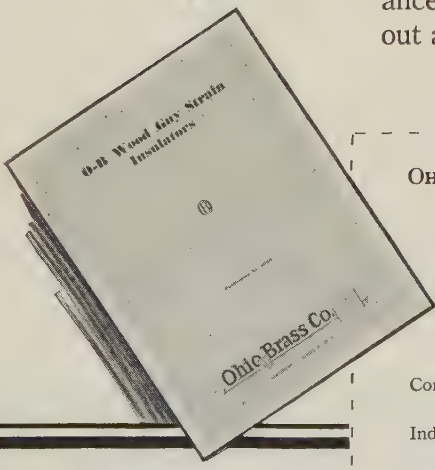

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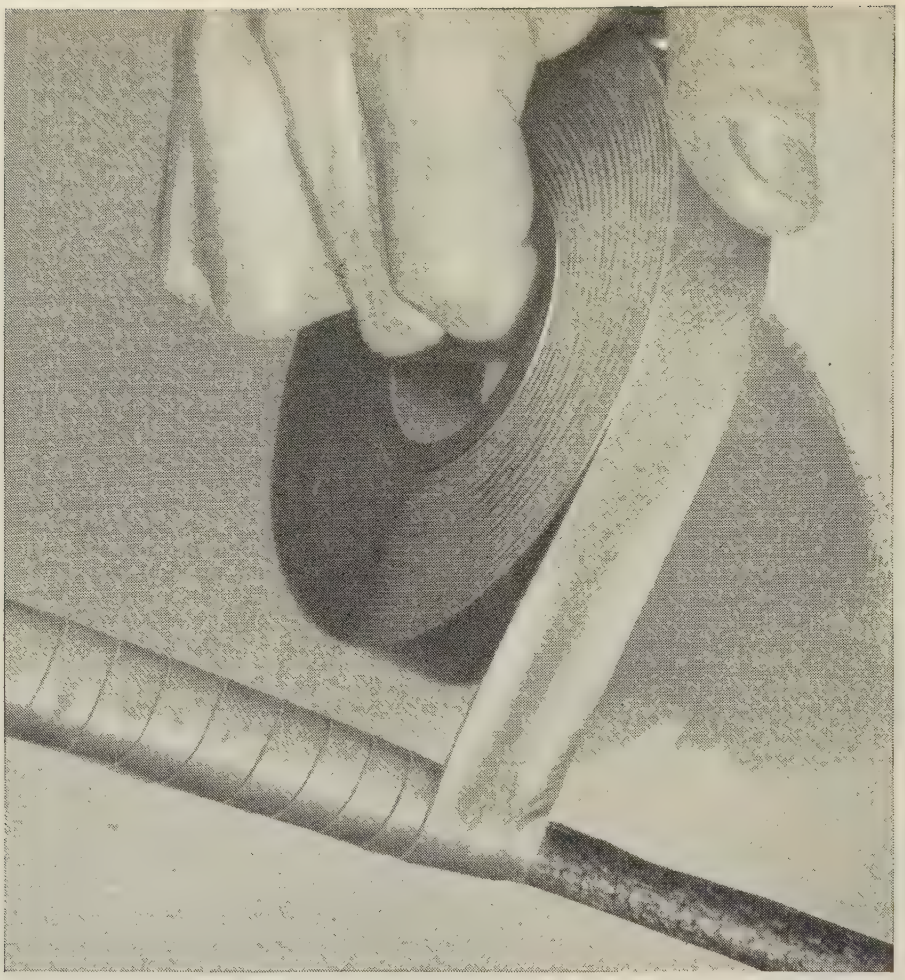

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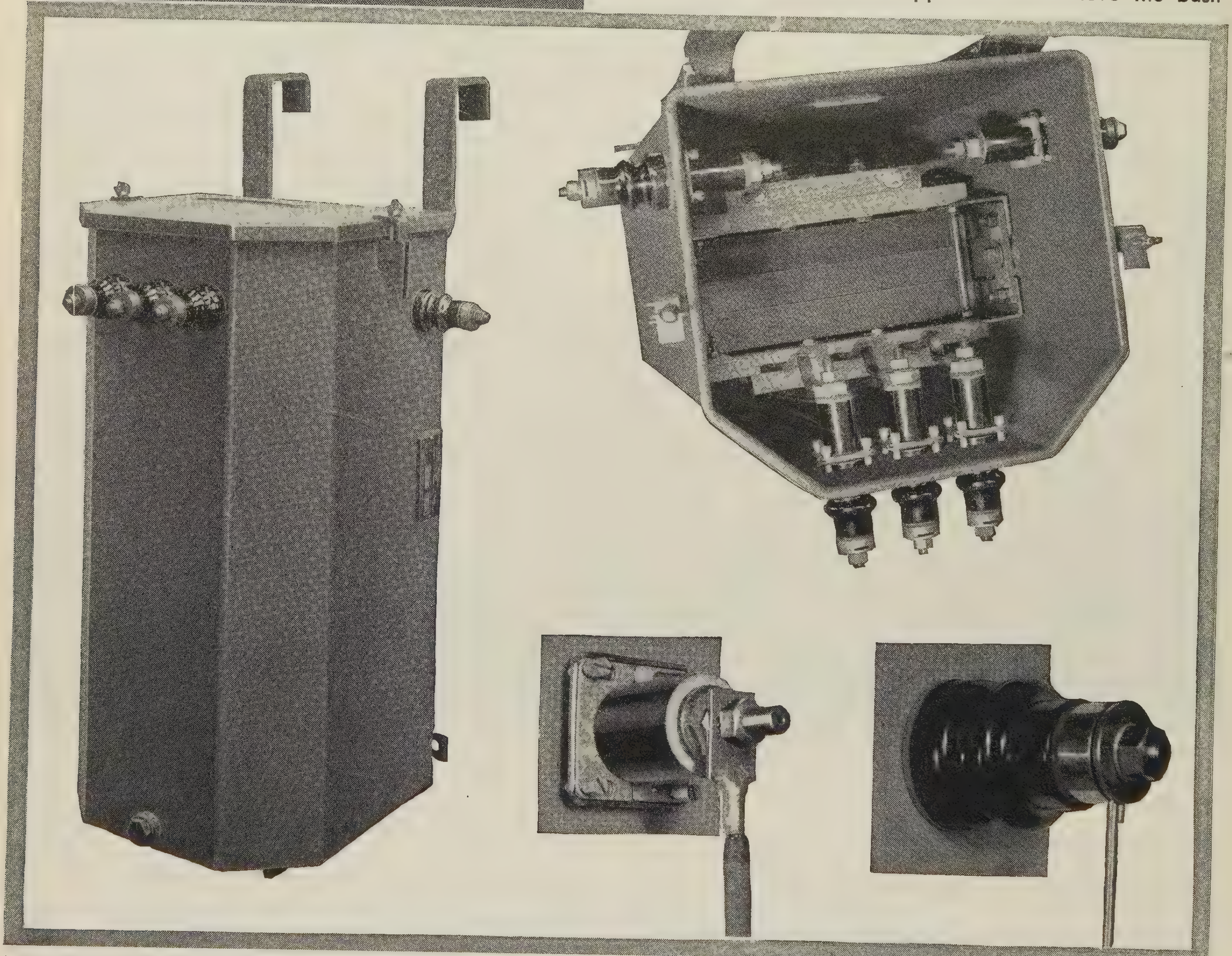

ing. » » » In the August 11th, 1928, issue of Electrical World there was published a table which showed that the average cost of raising and connecting a transformer ranged from $11.90 per 1 Kv-a. to as much as $59.52 per 50 Kv-a. When stud-type transformers are used, such expenses are practically eliminated when bushings and line connections require servicing. » » » The subject of stud-type bushings is fully discussed in Section 2D, pages 1 to 6, of Wagner's Bulletin 172. These pages have just come off the press. Ask for copies. » » »

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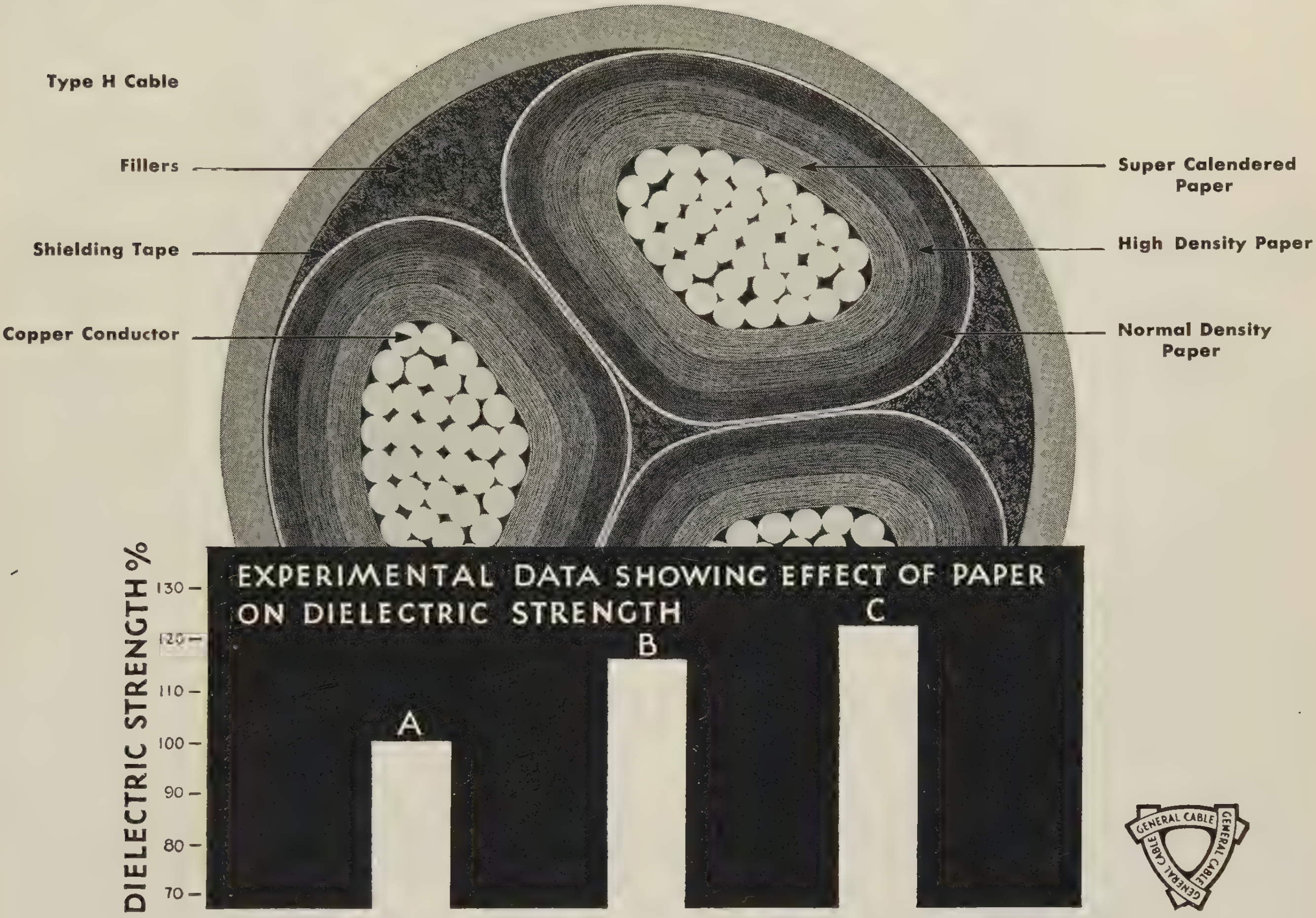

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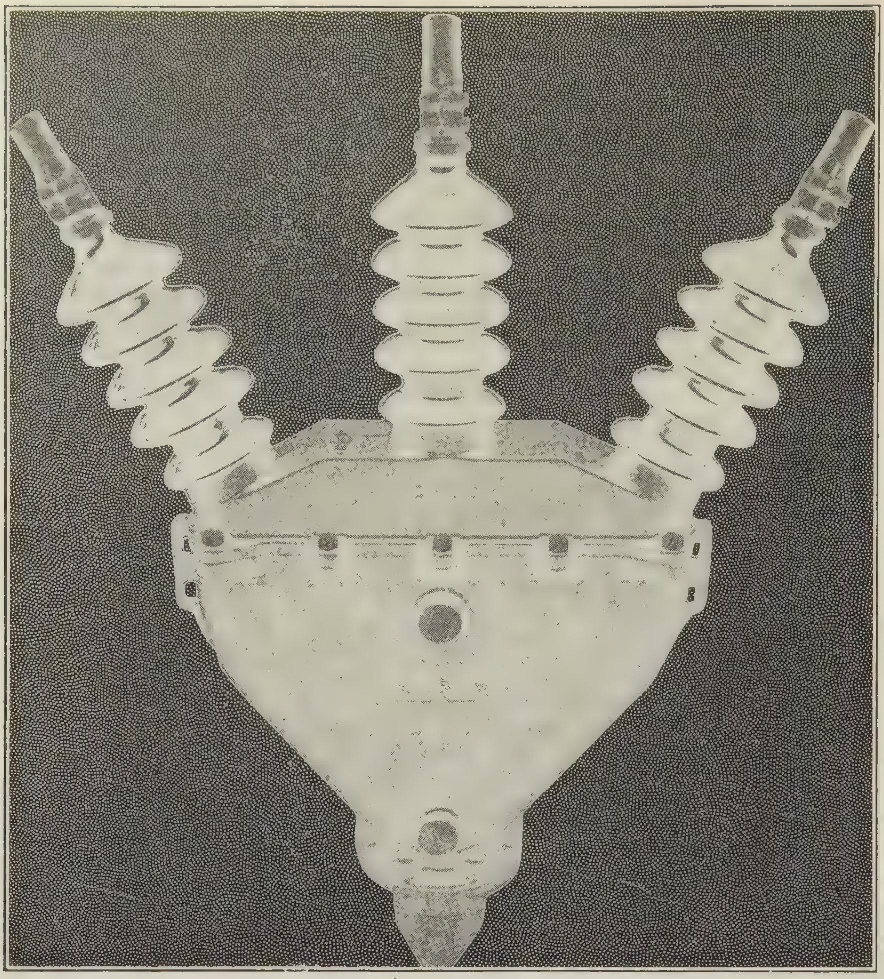

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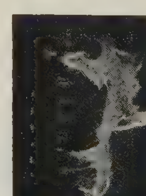

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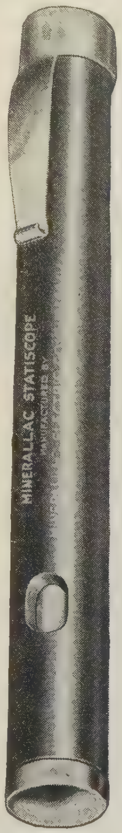
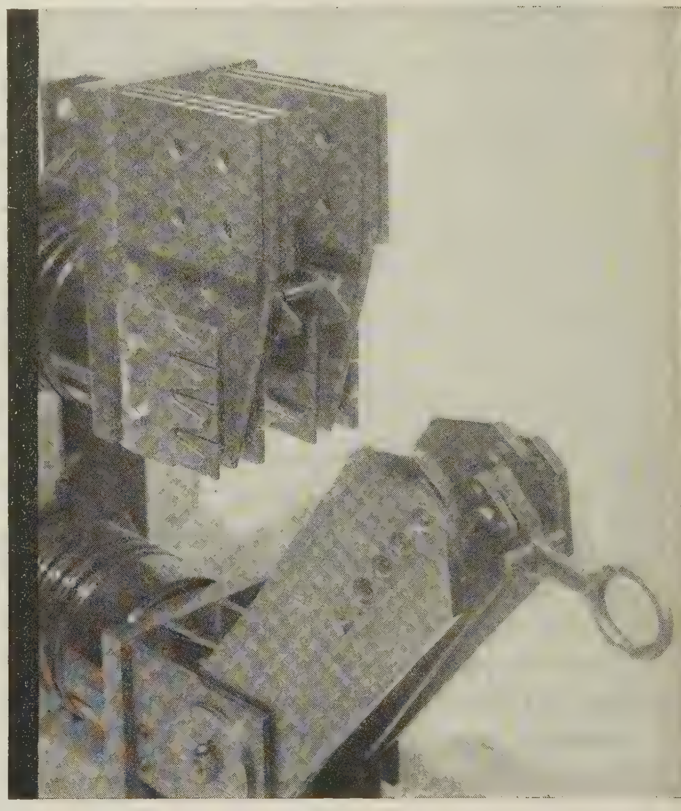
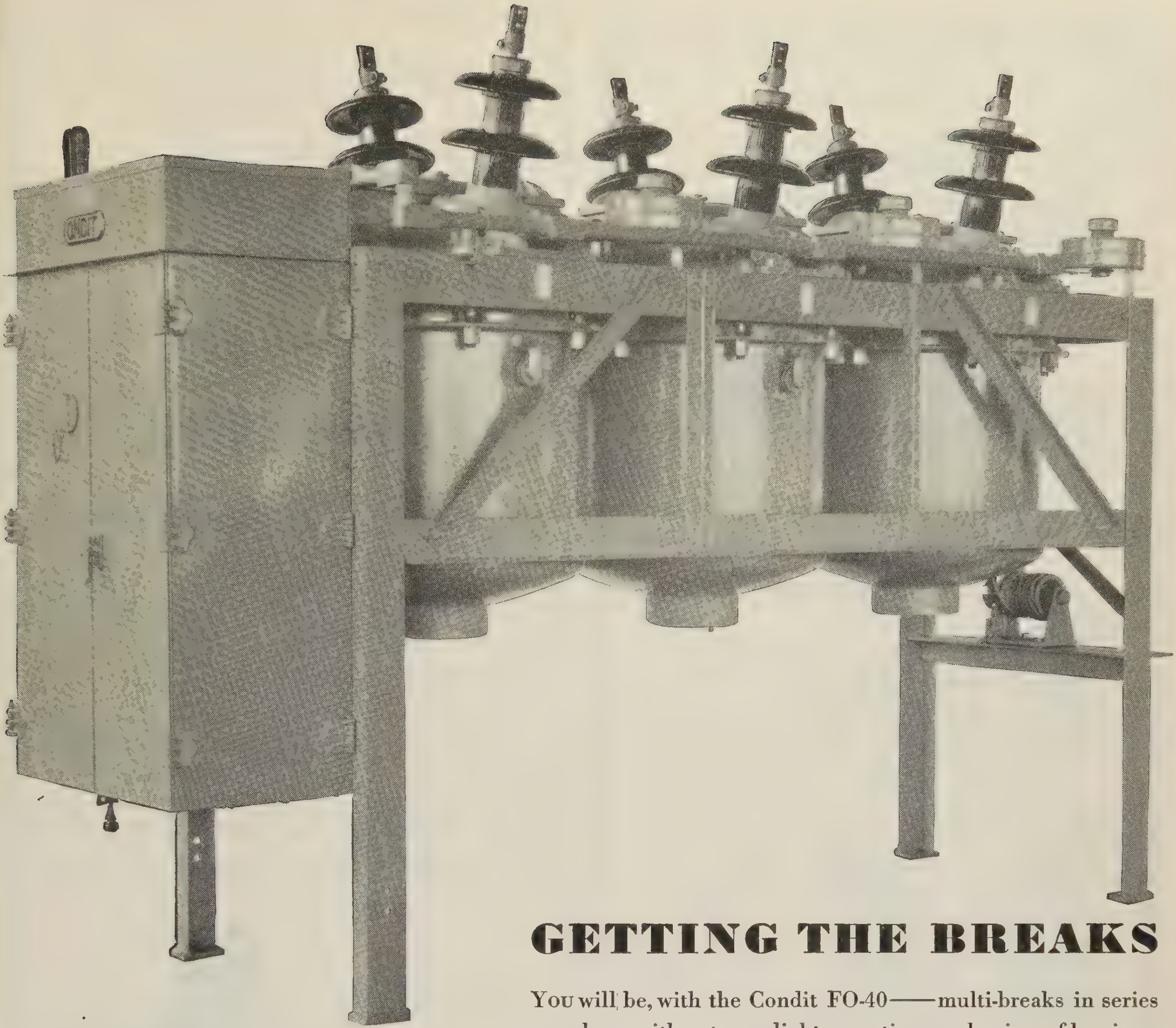


(The Pocket Type)





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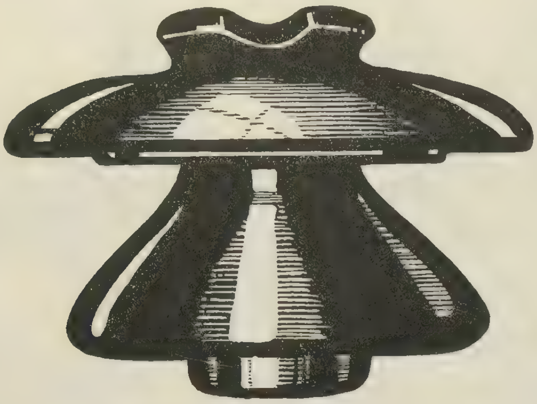
INSULATORS



PINCO No. 1125

No Cement

Operating Voltage	45	Kv.
Dry Flashover Voltage	140	Kv.
Wet Flashover Voltage	100	Kv.
Leakage Distance	20¾	Inches
Mechanical Strength	4500	Lbs.

(No. 1123 for 30 Kv. and No. 1124 for 37.5 Kv.)

Rugged one-piece pin-type insulators made of wet process porcelain. These units, first introduced by Pinco engineers and made by the Patented Harvey Process, have solved operating problems on important lines in nineteen states. Send for complete information.

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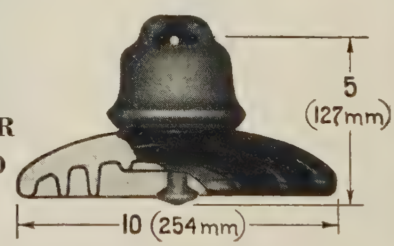
No. 4700



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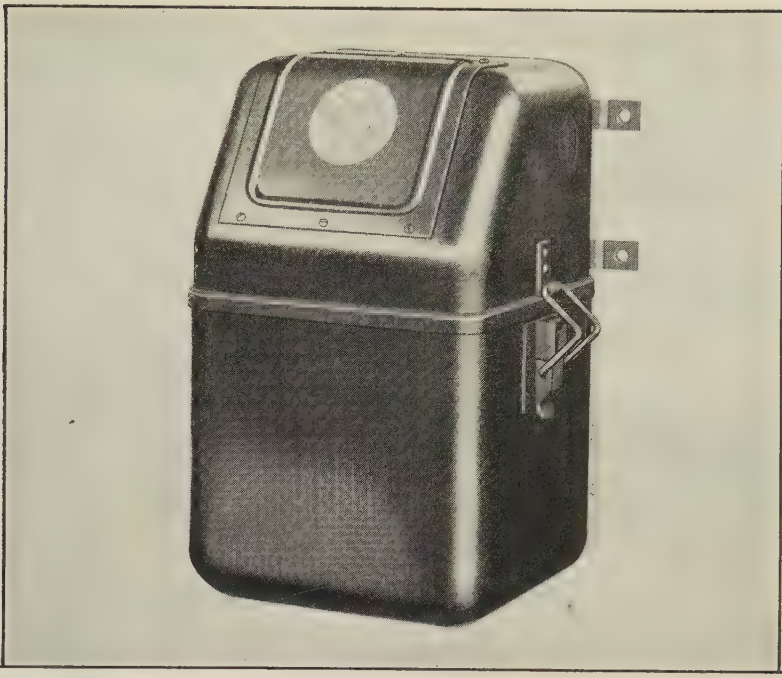
LARGER HORSEPOWER



New No. 2
E C & M Type ZO Motor Starter

No. 1 ZO

A Larger Companion for the No. 1 ZO

LIKE the No. 1 Type ZO, this new and larger Across-the-line Motor Starter is a self-contained unit, totally enclosed in a heavy (16 gauge) pressed steel case with oil-immersed main and control circuit contacts and vapor-proof overload relays. It is liberally designed and sturdily built to withstand service that may require severe and frequent starting duty. The entire unit is of very compact design requiring little mounting space and is of dust-tight construction.

Thermal type overload relays are used in this starter. These are accurately designed to protect motors against single phase and overload conditions and have high heat inertia to withstand 10 to 20 times full load motor current without injury. Heater elements are easily changed so that a No. 2 Type ZO Motor Starter of one rating can be easily and quickly converted to one of another horsepower rating.

EC&M No. 2 Type ZO Motor Starters are exceptionally quiet in operation, employing a new and highly efficient magnetic circuit. Complete description is given in a new folder, just off the press. Write for a copy.

Maximum Ratings of No. 2 ZO

Standard Motors

20 H P	*220 volts*
40 H P	*440 volts*
40 H P	*550 volts*

Motors with Low Inrush Current

30 H P	*220 volts*
60 H P	*440 volts*
75 H P	*550 volts*

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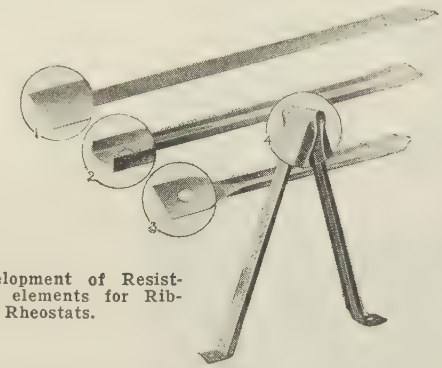
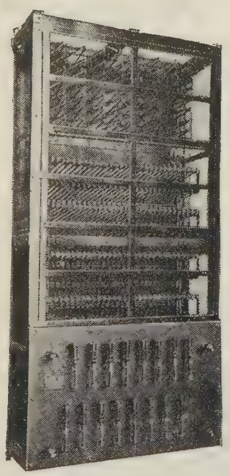
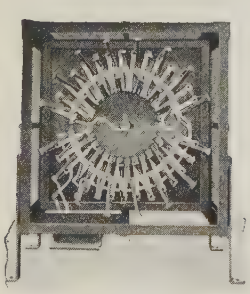


Development of Resistance elements for Ribohm Rheostats.

WARD LEONARD
RIBOHM
Rheostats—Resistors



Laboratory loading rheostat employing Ribohm as the resistive element.



Ribohm Field Rheostat, single face plate, rear view.

REPEATEDLY, the factors leading to the selection of Ward Leonard Ribohm Rheostats and Resistors are light weight, great heat radiating capacity, permanence of resistance value and freedom from breakage due to vibration.

Weight for weight the continuous watt dissipation of Ribohm is greater than that of any cast grid type of resistor.

Because of their compactness for a given watt capacity, Ribohm saves considerable floor space.

Ribohm is made of a rolled and cold-pressed, special alloy ribbon which will not crystallize in service.

Some applications profiting by the economies of Ribohm are battery charging, generator field control, motor control, electroplating, projection and searchlight control, and air heaters.

Write for Bulletin 73 describing further the applications and advantages of Ribohm Rheostats and Resistors.

WARD LEONARD ELECTRIC CO.
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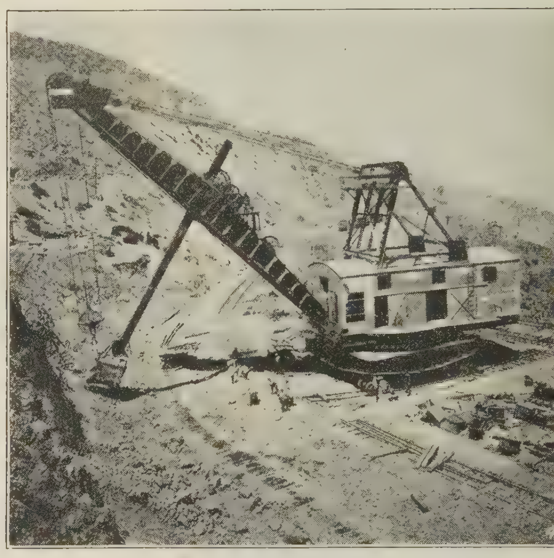
Protect investments with TIREX CABLES



Insure your electric shovels and other portable equipment against delays due to cable trouble by specifying TIREX Cables. Service records show that TIREX Cables guard against losses to equipment, time, and material - all of which make deep inroads upon the revenue received for your product.

A construction feature, obtainable only on TIREX, is an outer sheath of carefully compounded "selenium rubber." This special rubber sheath retains its flexibility, toughness and wear resisting qualities indefinitely making TIREX particularly desirable for service on electric shovels.

When cables must be replaced on equipment already in service, standardize on TIREX and secure the many advantages it offers - long life, freedom from trouble, permanency and reduced yearly maintenance costs.

Through the co-operation of our Engineering Department many mining companies are obtaining cables to meet unusual operating conditions. It is possible that we can help solve your cable problems. Write for TIREX samples and more complete information.

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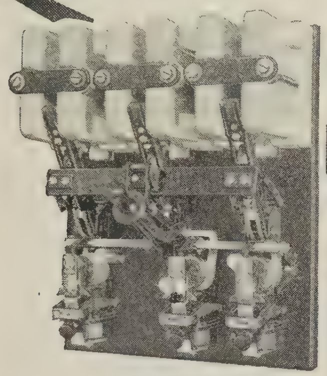
3 MAJOR DEVELOPMENTS IN AIR CIRCUIT BREAKERS

MIN-ARC-ITE

RE-AX-ITE

DUAL OVERLOAD



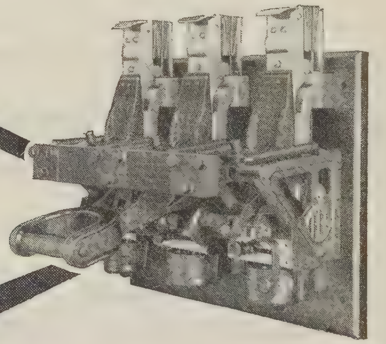
MIN-ARC-ITE — the new I-T-E Arc Extinguisher — is the answer to the increasing demand for higher interrupting capacities and shorter arc duration. It is equally as effective for D. C. as for A. C.

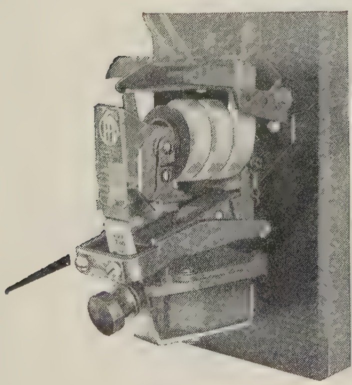
WHAT MIN-ARC-ITE DOES

(1)—Greatly decreases size and time of arc.
(2)—Reduces to a minimum the ionized gases emitted on shorts.
(3)—Adds protection to main contacts and speeds breaker opening.
(4)—Increases rupturing capacity and therefore increases factors of safety.

RE-AX-ITE Carbon Supports are the latest development of a magnetic principle established by I-T-E 31 years ago. Re-Ax-Ite Carbon Supports:

(1)—Speed the opening on short circuits.
(2)—Increase rupturing capacity by affording positive protection to main contacts.
(3)—In combination with Min-Arc-Ite Barriers, provide materially higher interrupting capacity.





DUAL OVERLOAD — An exclusive I-T-E feature. Discriminates between desired overloads and non-desired overloads or shorts.

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(2)—Extremely selective, due to double armatures.
(3)—The most dependable device for starting A. C. motors across the line, giving full protection against sustained overloads and instantaneous opening on shorts.

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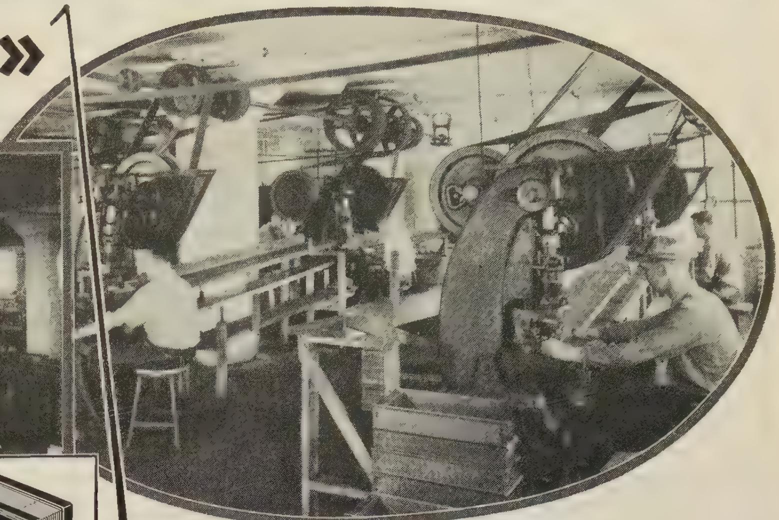

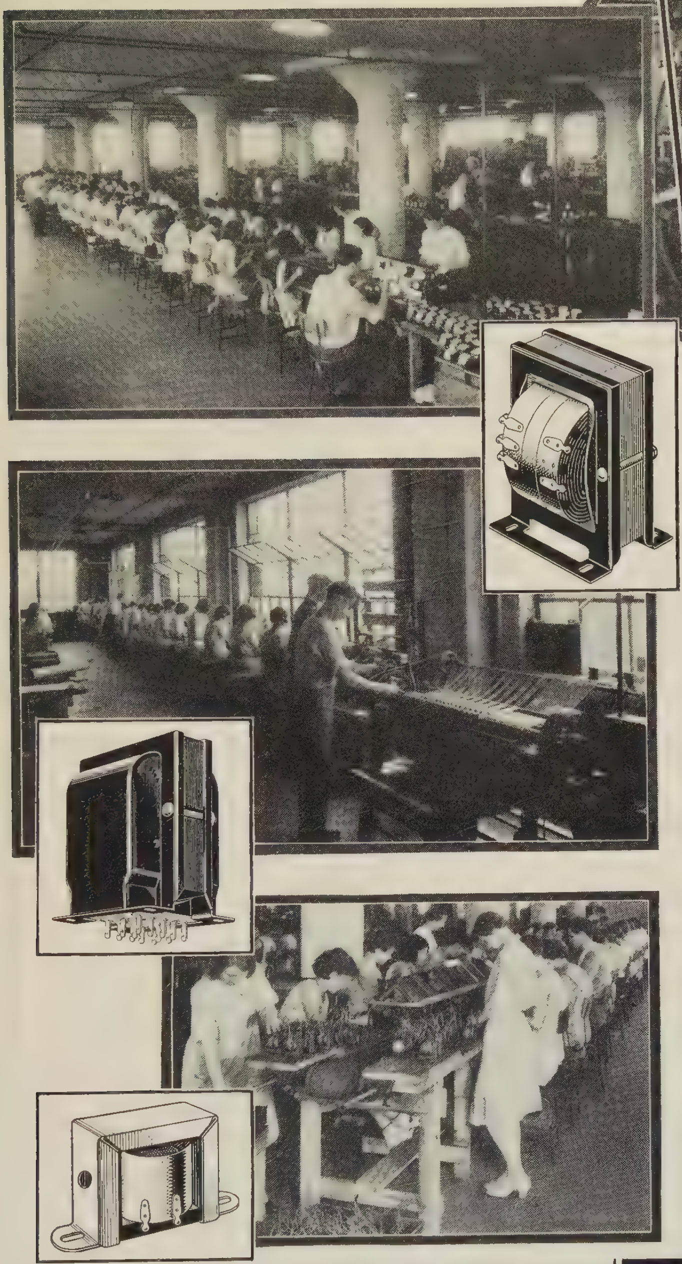

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Index to Advertised Products—*Continued*

Index to Advertised Products—*Continued*

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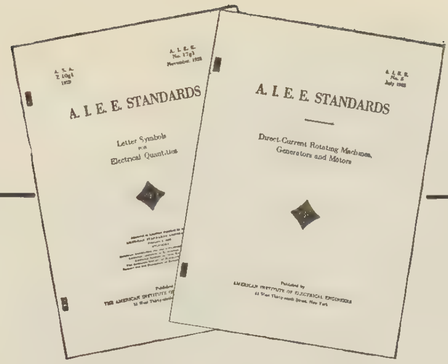

THE STANDARDS of the American Institute of Electrical Engineers now cover thirty-eight distinct types of electrical machinery and apparatus. They are chiefly devoted to defining terms, conditions and limits which characterize behavior with special reference to acceptance tests. Many of the standards are recognized officially as American standards.

The Standards are available in pamphlet form as listed opposite.

No.		
1	General Principles upon which Temperature Limits are Based in the Rating of Electrical Machinery	$ 0.20
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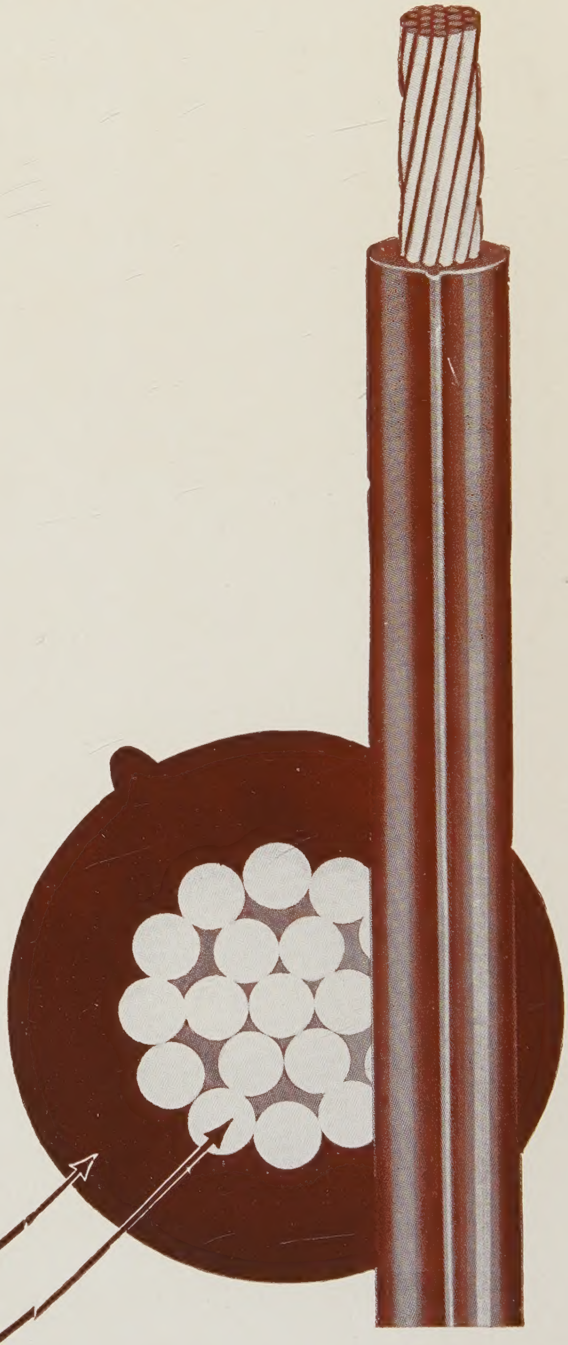

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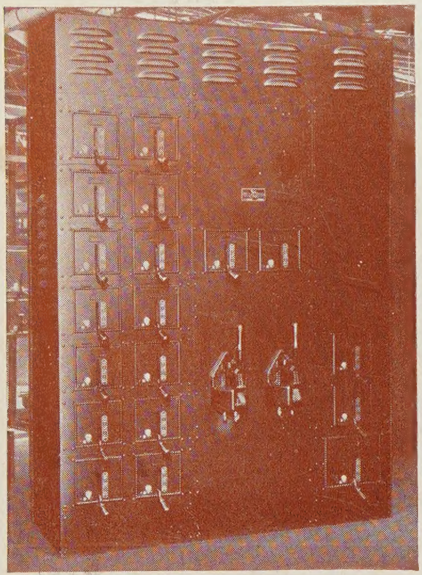

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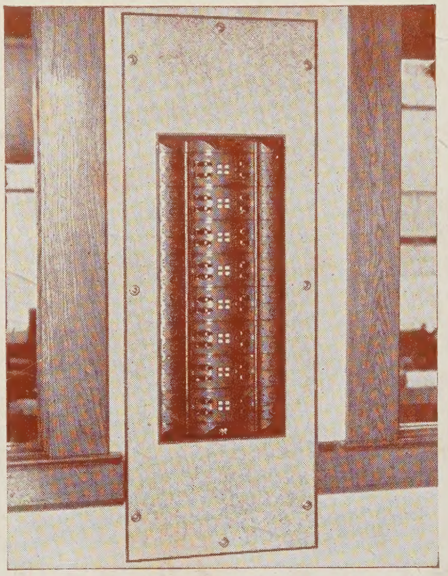

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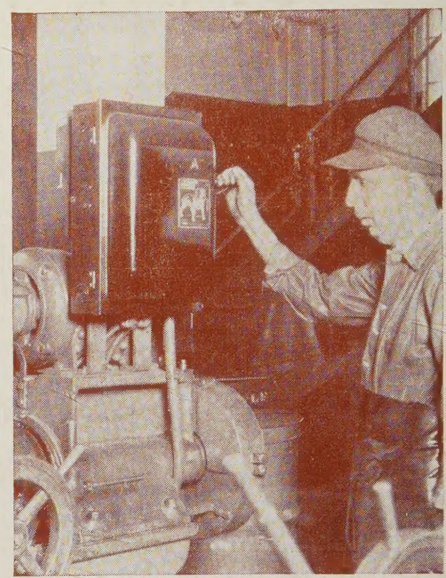

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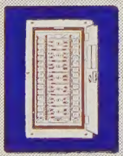

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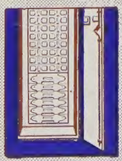

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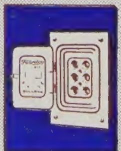

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